

ECOLOGY OF THE JERDON'S COURSER (*Rhinoptilus bitorquatus*) IN INDIA

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Submitted

By

P. Jeganathan

Under the guidance of

Asad R. Rahmani, Ph. D

Bombay Natural History Society

Hornbill House, Shaheed Bhagat Singh Road, Mumbai – 400 023

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STATEMENT BY THE CANDIDATE

As required by the University Ordinance 770, I wish to state that the work embodied in this thesis titled “Ecology of the Jerdon’s Courser (*Rhinoptilus bitorquatus*) in India” forms my own contribution to the research work carried out under the guidance of Dr. Asad R. Rahmani at the Bombay Natural History Society, Mumbai. This work has not been submitted for any other degree of this or any other University. Whenever the reference have been made to the previous work of others, it has been clearly indicated as such and included in the bibliography.

P. Jeganathan

Certified by

Asad R. Rahmani

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Chapter 1

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1.1 Coursers-An Introduction

Coursers are the members of the order Charadriiformes. They come under family Glariolidae and further classified into Subfamily Cursoriinae (Maclean 1996). Subfamily Cursoriinae consists of birds of two distinct types: Genus *Pluvianus* is represented by one species which is Egyptian Plover *Pluvianus aegyptius*, a riverine species of uncertain affinity (Cramp & Simmons 1983), and true coursers. Eight species of Coursers are present in three genera (Maclean, 1996):

- I. Genus *Cursorius* :- Four species - Cream-coloured courser *Cursorius cursor*, Burchells Courser *C. rufus*, Temminck's Courser *C. temminckii* and Indian Courser *C. coromandelicus*.
- II. Genus *Smutsornis* :- One species - Double-banded Courser *Smutsornis africanus*.
- III. Genus *Rhinoptilus* :- Three species - Three-banded Courser *Rhinoptilus cinctus*, Bronze-winged Courser *R. chalconotus* and Jerdon's Courser *R. bitorquatus*.

Coursers are long legged, medium sized (length ranging from 19-28 cm) terrestrial birds, which have pointed wings, arched and pointed bill. They affect drier parts of the Old world tropics, with greatest diversity in Afro-tropical regions. Out of nine species of this subfamily, seven are found in Africa. Among them four species of coursers are restricted to African continent (Maclean, 1996). The other two species are found only in the Indian subcontinent (Ali & Ripley 1987)

Coursers found predominantly in dry and open areas and prefer low altitudes. They lack hind toe in their legs and are adapted to terrestrial way of life and they are very good runners. The representatives of the Genus *Rhinoptilus* and *Smutsornis* are largely nocturnal or crepuscular in habit. Rest of them are diurnal. Coursers are generally gregarious, but found in loose flocks. Most of the coursers have well camouflaged plumage. The food of all coursers is chiefly insects. They catch their food from the ground in plover like habit. The coursers of Genus *Cursorius* possess relatively long and pointed beak adapted to digging the insects. Coursers have functional nasal gland for the excretion of excess salt. Coursers are ground nesters. They lay their eggs in the

ground or in a shallow scrape. The eggs and the fledgling show oblitative colouration that helps in avoiding the predators. Both sexes help in parental care activities. Young ones are precocial (Maclean 1996).

Although none of the representatives of subfamily Cursoriinae is extinct since 1600, some of them are locally extinct within their distributional range (e.g. Egyptian Plover) and some others restricted to the small patch (e.g. Jerdon's Courser). And also they are facing long term declines due to destruction of their habitat by overgrazing by domestic stock and deforestation (Maclean 1996).

1.2 Indian Cursoriinaes

Three species of Coursers belongs to two genera namely Genus *Cursorius* and Genus *Rhinoptilus* are found within Indian limits. While the former has two representatives, later only one (Grimmett *et al.* 1998). Subfamily Cursoriinae is the least studied group of birds (Maclean 1967). Very little biological work has been done on Indian *Cursoriinaes* so far. Most of the literatures about the Indian *Cursoriinaes* are only either short notes or survey and sight records (e.g. Sharma 1986, Rahmani & Manakadan 1989, and Santharam 1996).

1.2.1 Indian Courser *Cursorius coromandelicus*

The Indian Courser is a graceful lapwing-like bird with rich orange under parts contrasting with grey brown upper parts, blackish belly, crown chestnut in colour, bill slightly arched and no hind toe (Grimmett *et al* 1998). No quantitative study has been carried out so far in India about this species. Sighting records from various places (Parker 1875, Inglis 1913, Phillip 1942, Brookeworth 1953, Stairmand 1971, Roberts 1991, Santharam 1996) states that it is widespread but patchily distributed throughout the Indian subcontinent. It is rare on the Malabar Coast and it usually avoids areas of heavy rainfall as well as pure deserts (Baker 1929, Ali & Ripley 1987). However, during monsoon, it is widespread in the Thar Desert, and possibly breeds there (Rahmani, 1997).

Several records show that it is usually found in loose flocks and breeds in dry and open areas (Baker 1929, McCann 1926, Stairmand 1971, Paresh 1989, Siddaramaiah & Jayadeva 1992). The habits are much like Stone Curlew *Burhinus oedipnemos*, run about quickly and abruptly stops to pick up the insect. Breeding season varying locally April to June in Central India, and March to July in Western India. Usually 2 eggs on the ground, some times 3 eggs stone coloured, thickly spotted and blotched with black (Blanford 1898). In Sri Lanka breeding season will begin in June, eggs laid on the bare ground among the debris (Phillips 1942).

Young birds dull buff above and irregularly barred with blackish brown, colour of eggs and hatchlings exactly match the surroundings (Baker 1929). Mainly feeds on insects. In Pakistan main food is ground living *Tenebrionoid* beetles and the soil born larvae and pupae of insects, ants and mole cricket (*Gryllotalpa* sp.) and larvae of grass-hoppers (Mason & Lefroy, 1912). Migrates locally according to rainfall and food availability (Roberts, 1991 and Rahmani, 1997). Endemic to the Indian subcontinent.

1.2.2 Cream-Coloured Courser *Cursorius cursor*

Among the Coursers this is the only species having widespread distribution. Found in Africa, Arabia, Europe and in Indian subcontinent (Maclean 1996). Inhabitant of desert areas, behaviors are very much like those of Stone Curlews. Flies strongly and rapidly (Baker 1929). Easily distinguishable from the previous one from rufous colour in front portion of the crown and grey behind and pale sandy colour body (Grimmett *et al.* 1998). Gregarious, some times gather in small flocks and even associated with Indian Courser where their habitats overlap especially during monsoon. Believed to be a winter visitor (Baker 1930, Ali & Riply, 1987), but recently two authentic records from Northwest India (Sharma 1986, Rahmani & Manakadan 1989) established that they breeds within our limits.

It breeds in various part of the world within its distributional limits, e.g. Western Palearctic (Snow & Perrins 1998), Pakistan (Roberts 1991), and in Africa (Urban *et al.* 1986). They are largely insectivorous. Sometimes dig for food using bill and also catches the locust in flight

(Maclean 1996). They feed mainly on small dung beetles, *Tenebrionid* beetles and orthopteran insects also small molluscs (Mason & Lefroy 1912). Apart from this, larger prey such as Fringe-toed lizards (*Acanthodactylus cantoris*) and scorpions are also taken. Stomach contents from Socotra (Gulf of Aden) and Tunisia contain seeds (Roberts 1991).

Its breeding status in the Indian subcontinent is poorly known. Eggs were found in May in Pakistan (Grimmett *et al.* 1998) and prefledged clutch seen in July in Jaisalmer, India (Rahmani & Manakadan 1989). Unlike the previous species this courser prefers arid, open places and hot deserts.

1.2.3 Jerdon's Courser *Rhinoptilus bitorquatus*

The Jerdon's Courser is the sole representative of Genus *Rhinoptilus* in India and one of the world's rarest birds, and nocturnal in habit likes those of African counterparts. It has large eyes, and short yellow bill with black tip. Brown and white bands across the breast. Legs yellow in colour (Grimmett *et al.* 1998). First described by T. C. Jerdon in c.1848 "from the hilly country above the Eastern Ghats off Nellore and in Cuddapah district". Till the year 1900, a few sightings were had near Pennar river valley and near Godavari river valley (Baker 1929), and finally near Anantapur by Campbell in 1900 (Ali 1977), until it was rediscovered on 15th January 1986 in Pennar river valley after 86 years during the 'Endangered Species Project' executed by the Bombay Natural History Society and US Fish and Wildlife Service (Bhushan 1986a).

Before the rediscovery, efforts taken by various ornithologists to record this elusive species were unsuccessful (Whistler & Kinnear 1930, Ali 1933-34). Besides that special explorations organized by the Bombay Natural History Society in 1975 and in 1976 with the collaboration of Smithsonian Institution, Washington and World Wildlife Fund -India did not achieve positive results (Ali 1977). This led to a belief of that it is extinct (King 1981; Ripley 1982) until the rediscovery. The place where it was rediscovered was declared as a sanctuary for the Jerdon's Courser (Bhushan 1986b). Later on, the survey carried out by BNHS from May 1994 - October 1995 in Sri Lankamaleswara Wildlife Sanctuary to study the distribution and population of Jerdon's

Courser established more sightings of this elusive species in Cuddapah district (Samant & Elangovan 1997). Despite all these works except the sight records there is no quantitative study regarding their ecology and behavior. Virtually nothing is known about the food and feeding habits of Jerdon's Courser. There is no authentic information available about breeding, but the male collected in June 1900 by Howard Campbell had enlarged testes so it could be breeding (Baker 1929).

1.3 Rationale and Genesis of the study

There are 78 globally threatened bird species in India. Out of these, eight species are listed as critically endangered and the Jerdon's Courser is one among them (BirdLife International 2001). Since it is believed to have a small and declining population, it is categorised as critically endangered in the IUCN Red List as well (IUCN 2006). Out of three species of coursers occurring in India, the Jerdon's Courser is the only species which is endemic to India, and in particular restricted to Eastern Andhra Pradesh (Islam & Rahmani 2004). The Jerdon's Courser is listed under Schedule I of the Indian Wildlife (Protection) Act 1972, and is considered as priority species under the National Wildlife Action Plan (2002 – 2016) of the Government of India (Government of India, 2002). Except sight records, there is no information on current population size or geographical distribution. Furthermore, very little information is available on the ecology and habitat requirements of the Jerdon's Courser (BirdLife International 2001). So far the Jerdon's Courser was reported mainly from the scrub jungle habitat. It mainly inhabits sparse, scrub-forest interspersed with patches of bare ground, in gently undulating, rocky foothills (Bhushan 1986a).

Less than one-third of endemic birds in the Indian subcontinent affects scrub jungle habitat (Grimmett *et al.* 1998). Vegetation in dry and scrub habitat where Jerdon's Courser were reported are more fragile and damaged by human activities such as over exploitation for fodder, fuel wood collection or grazing and developmental activities (BirdLife International 2003). Scrubland is the key habitat for four threatened species of India (Islam & Rahmani, 2004).

It is extremely difficult to recommend measures to conserve any species and its habitat without studying the ecological requirement of that species. Therefore scientific and quantitative

study on the Jerdon's Courser is imperative for their long-term survival. The present study is designed to fill this gap in our knowledge of the ecological requirement, geographical distribution and other important ecological aspects of the Jerdon's Courser.

The study was funded by the Darwin Initiative for the Survival of Species, U.K. and was sponsored by the University of Reading and the Royal Society for the Protection of Birds (RSPB). The fieldwork was initiated as a preliminary survey in Sri Lankamaleswara Wildlife Sanctuary, Cuddapah district in September 2000 for about a week. Intensive fieldwork was conducted from December 2000 to November 2004 in and around Sri Lankamaleswara Wildlife Sanctuary, Cuddapah District, Andhra Pradesh. Part of the fieldwork was carried out in the western part of the Sri Penusula Narasimha Wildlife Sanctuary, which falls under Cuddapah Forest division.

1.4 Objectives of the study

The overall objective of this study was to undertake ecological research on the Jerdon's Courser to determine current population size and distribution, and identify current threats to the populations. This involved five specific objectives:

1. To design a proper and reliable census method,
2. To identify areas of suitable habitat within its known range and conduct survey to establish its current geographical distribution,
3. To examine habitat use to determine habitat requirements,
4. To asses potential threats,
5. To develop management plan and to make recommendations for its conservation based on survey findings, research and monitoring work, which includes the details of required conservation action, establishment of sites supporting populations as protected areas.

Chapter 2

Study Area

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2.1 Study area

This study was carried out in the Tropical dry thorn forests of the Lankamalai and Velikonda Hills, which are in the middle part of Eastern Ghats. Biogeographically Eastern Ghats falls in the Deccan Peninsula and provides centers of endemism for plants, birds and wildlife (Rodgers & Panwar 1988).

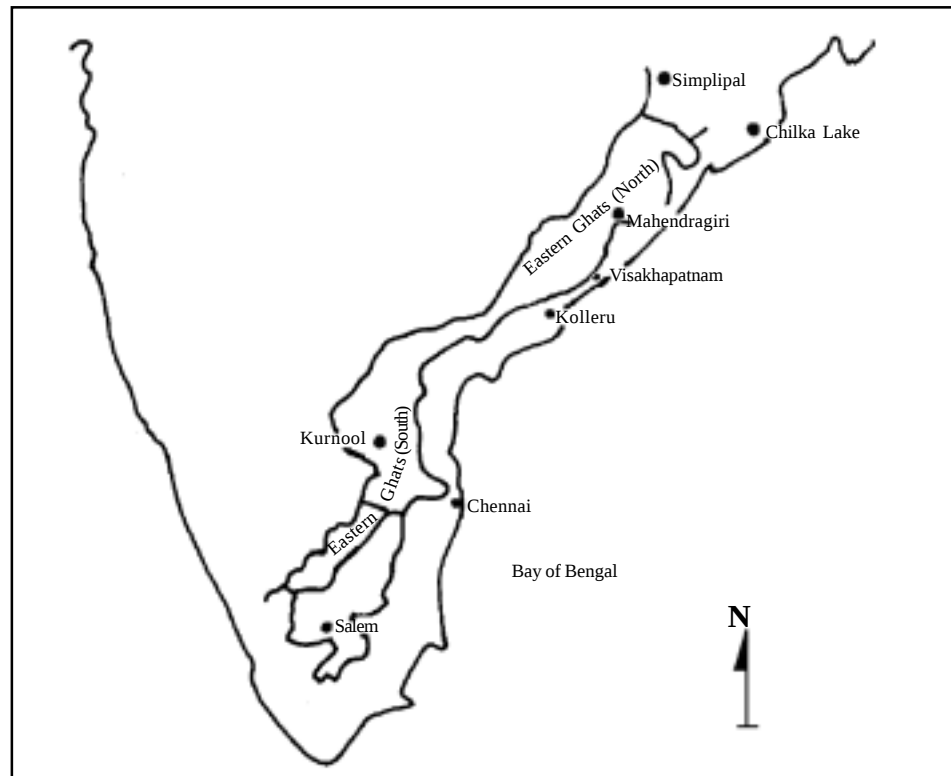
In the coming sections some of the key features of the Eastern Ghats are discussed and followed by the accounts of the Sri Lankamaleswara and Sri Penusila Narasimha Wildlife Sanctuaries where the study was conducted intensively.

2.2 The Eastern Ghats

2.2.1 Physiography

The Eastern Ghats, hill ranges lying along the coastal plains of east coast of the peninsular India, extend from Orissa to Tamil Nadu passing through Andhra Pradesh, between 11° 31' and 21° 0' North and 77° 22' and 85° 21' East (Map 2.1). The Eastern Ghats consist of about 75,000 sq. km with an average width of 200 km in the north and 100 km in the south. This area is spread over 1, 750 km between the Rivers Mahanadi in the north and Vaigai in the south (Pullaiah 2002).

Mahanadi basin forms the northernmost boundary and the Nilgiri Hills form the southern boundary of the Eastern Ghats. In the west, the Eastern Ghats merge with the tips of the Bastar, Telangana and Karnataka plateaux and Tamil Nadu uplands, while the coastal areas in the east limit its eastern part (Pullaiah 2002). The Eastern Ghats are not contiguous because the rivers Mahanadi, Godavari and Krishna cut across them (Pullaiah 2002). There is a 130 km gap in the Ghats in the Guntur district, and then the middle Eastern Ghats start and extend from the Krishna, consisting the Nallamalais, Palakonda, Velikonda and Seshachalam Hills (Pullaiah 2002). The southern Eastern Ghats run towards the Western Ghats in southwestern direction and meet in the Nilgiris. This section includes the Javadi Hills, the Kollimalai, the Pacchamalaim, the Kalrayan, the Shevaroy and the Biligirirangan Hills, which forms the southern tip of the Eastern Ghats.

Map 2.1 Location of Eastern Ghats in India (Pullaiah, 2002) (Map not to Scale).

The Eastern Ghats are an assemblage of discontinuous hill ranges, plateaus and escarpment with an elevation ranging from a few meters to 1750m. Elevation in the northern Eastern Ghats is about 400 m in the plains and the highest peak is Mahendragiri 1501 m, whereas the average elevation in the middle Eastern Ghats is about 750 m. The highest peak in the southern Eastern Ghats region is 1750 m in the Biligirirangan Hills (Pullaiah 2002).

2.2.2 Geology

The Eastern Ghats consists of an intensely deformed and metamorphosed assemblage of metasedimentary, basic and enderbitic granulites interspersed with massif-type anorthosites (Pascoe 1950). The Eastern Ghats Belt (or Eastern Ghats Mobile Belt, Eastern Ghats Granulite Belt) is one of the oldest groups of rocks (average age of about 2900 million years) of Indian peninsula. It consists of a contiguous terrain of high-grade metamorphic rocks at the eastern coast of peninsular India. The older sedimentary rocks of Eastern Ghats have intensely metamorphosed and grouped under Charnockites, Khondalites, Granites, Granodiorites and unclassified Granulites (Pascoe 1950).

The Eastern Ghats Belt is prominent in Andhra Pradesh and it is extending NE-SW 600 km in the state along the coast with a width varying from 100 km to 20 km. Andhra Pradesh represent defined tectonic elements, which contains the Archaean, the Middle-Upper Proterozoic and the Gondwana strata (Raman & Murthy 1997).

Another important feature of the Eastern Ghats is the Cuddapah Supergroup. It is the Proterozoic cover of flat sedimentary rocks occurs in a crescent shaped basin. Most of the basin is covered by rocks of Cuddapah Supergroup of Upper Proterozoic age. This Supergroup consists of about 6000m thick succession of alternating quartzite (sandstone) and shale (slate) with some limestone (Wadia 1966). The main minerals found in this region are iron ore, manganese, uranium, dolomite, coal, limestone, granite, aluminous laterite and bauxite and the major soil types found here is rocky soil (leptosols), red loamy, alluvial and black soil (Vertisols) (Ramachandran 1999).

2.2.3 Climate

The Eastern Ghats region falls under tropical monsoon climate. The rainfall in Eastern Ghats region is influenced by both the south-west and north-east monsoons. Northern part of the Eastern Ghats receive 1200 to 1600 mm, whereas central and southern part receives only 600 to 1000 mm. Central part of the Eastern Ghats has semi-arid climate. In the coastal plains cyclonic storms are frequent during the rainy season. The temperature in January ranges between 20°C and 25°C, and the maximum temperature rise up to 41°C during the summer months and the minimum is 5°C in the winter. The relative humidity varies from 70 to 75% during the rainy seasons (Pullaiah 2002).

2.2.4 Vegetation

Eastern Ghats are very rich in biodiversity. Reddy *et al.* (2002) estimate 3000 flowering plant taxa occurs in the Eastern Ghats of which 454 species are endemic to this region. Olson & Dinerstein (1998) categorized the forests of the northern part of Eastern Ghats as tropical, subtropical and monsoon broadleaf, which is classified under the Indo-Malayan biogeographic realm. Also it is considered as globally important ecoregion and the conservation status is categorized as vulnerable (Olson & Dinerstein 1998). Eastern Ghats falls under six terrestrial

ecoregions namely Eastern Deccan dry-evergreen forests, Eastern highlands moist deciduous forests, Northern dry deciduous forests, Central Deccan plateau dry deciduous forests, South Deccan plateau dry deciduous forests, Deccan thorn scrub forests (Wikramanayake *et al.*, 2002).

2.2.5 Fauna

Comprehensive information on the fauna of the Eastern Ghats is lacking. Although not exceptional in terms of endemism and diversity, the Eastern Ghats harbor several of India's large, threatened vertebrates such as the Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Asian elephant (*Elephas maximus*), Gaur (*Bos gaurus*), Wolf (*Canis lupus*), Wild dog (*Cuon alpinus*), Sloth bear (*Melursus ursinus*), Chousingha (*Tetracerus quadricornis*), Blackbuck (*Antelope cervicapra*), Chinkara (*Gazella bennetti*), Malabar Giant squirrel (*Ratufa indica*) and Grizzled Giant squirrel (*Ratufa macroura*) (Krishna Raju *et al.*, 1987). Other important mammals such as Nilgai (*Boselaphus tragocamelus*) and Tree shrew (*Anathana ellioti*) are also found here. As far as Andhra Pradesh part is concerned, 27 mammal species were reported (Krishna Raju *et al.*, 1987). Slender loris *Loris tardigradus lydekkerianus* is one of the subspecies of southern India, found in the dry and mixed deciduous forests of the Eastern Ghats (Singh *et al.*, 1999 & Singh *et al.*, 2000). Daniels (2000) reports 115 species of amphibians and reptiles from the Eastern Ghats and one among them is the Golden Gecko *Calodactylodes aureus*, which was rediscovered from Chittoor in 1986 (Daniel *et al.* 1986).

2.2.6 Birds of Eastern Ghats

Though the Eastern Ghats is rich in avifaunal diversity, it has received relatively little attention by biologists (Ripley *et al.*, 1987). There are only two systematic and comprehensive ornithological surveys undertaken so far in the entire Eastern Ghats region. They are the Vernay scientific survey of the Eastern Ghats (Whistler & Kinnear 1930-37) and the Hyderabad State Ornithological Survey (Ali 1933-34). Other significant works on birds mainly in northern part of Eastern Ghats has been done by Abdulali (1945, 1953), Krishna Raju (1985), Trevor Price (1979), Ripley *et al.*, (1987-88), and Beehler *et al.*, (1987). And in the central part mainly in Andhra Pradesh by Bhushan (1994).

The southern part of Eastern Ghats supports nearly 400 species and subspecies of birds (Bhushan, 1994). The critically endangered Jerdon's courser *Rhinoptilus bitorquatus*, which was rediscovered, recently (Bhushan, 1986a & 1986b) is endemic to Eastern Ghats. Apart from this, the Yellow-throated bulbul *Pycnonotus xantholaemus* which is endemic to southern peninsular India, is also found in central and southern part of Eastern Ghats. Taher & Pittie (1989) recorded 494 species and subspecies of birds in Andhra Pradesh alone. Eighteen more species were added after seven years and it makes the total of 512 for this state alone (Taher & Pittie 1994), many of them found in the Eastern Ghats.

The occurrence of Tree Sparrow *Passer montanus*, Abbot's Babbler *Malacocincla abbotti* and Little Spiderhunter *Arachnothera longirostra* in northern part of Eastern Ghats is of zoogeographical interest since these species are considered as Himalayan/Southeast Asian relicts (Beehler *et al.*, 1987). The Eastern Ghats in the southern most part runs in a Southwest direction meeting the Western Ghats. Species such as Yellow-browed bulbul *Iole indica* and White-bellied treepie *Dendrocitta leucogastra*, which are mainly confined to Western Ghats are found in this region as well (Ali & Ripley 1987). Apart from these resident species, the Eastern Ghats is an important flyway for winter visitors. Coastal wetlands and forested watershed in the Eastern Ghats hill ranges act as an important wintering ranges for migrant bird species (Bhushan 1994).

2.2.7 Land use, human impact, and loss of forest

Information available on the land use, human impact and loss of forests for the entire Eastern Ghats is discrete and not comprehensive. State of Forest Report 2001 assesses the forest cover for up to 1999 in Orissa, Andhra Pradesh and Tamil Nadu. These are the three states where the Eastern Ghats lies. The total forest cover is 1,10,339 km². It should be noted that this assessment includes forested areas other than the Eastern Ghats region within these three states. When compared to the 1987 assessment there is 9.8% decline in the forest cover in 12 years time (State of Forest Report 2001). In Orissa and in the northern Andhra Pradesh where major parts of the northern Eastern Ghats exist, the podu cultivation (*jhum* or shifting cultivation) is the main factor, which significantly reduces the forest areas (Krishna Raju 1982). Over grazing, mining activity, introduction of the exotic plant species, clear felling the forest for monoculture and coffee

plantation adversely affected the forests and the wildlife of Eastern Ghats (Krishna Raju 1987).

Impact of the loss of forest on the biodiversity of Eastern Ghats were documented in the northern and in central part of Eastern Ghats by Krishna Raju (1982), Beehler *et al.*, (1987), Price (1990) and Vikram Reddy & Prasad Rao (2002). Recent studies on forest cover changes based on remote sensing and GIS conducted in the southern portion of the Eastern Ghats in Tamil Nadu mainly in the Shervarayan, Chitteri and Kolli hills clearly show that forest areas are under severe anthropogenic pressures (Balaguru 2002, Jayakumar *et al* 2002, Natarajan *et al.*, 2004, Balaguru *et al.* 2003). There has been a loss of 71 % in the dense forest and 79.31% of forested area was encroached for monoculture plantations in nineteen years time in the Shervarayan hills (Balaguru 2002). Change detection analysis of forest of Kolli hills reveals that 25 ha loss in dry evergreen forest and about 35 ha and 1,306 ha in semi-evergreen and dry deciduous forests respectively between 1990 and 1999 and the main reasons for this change are severe fuel-wood extraction, illegal felling and intensive grazing (Jayakumar *et al* 2002).

2.3 Sri Lankamaleswara Wildlife Sanctuary

2.3.1 Location and extent

A major part of the study was carried out in and around the Sri Lankamaleswara Wildlife Sanctuary (SLWLS), Cuddapah district, Andhra Pradesh, India. Geographically, SLWLS lies between the Nallamalais and Sechachalam hill ranges in the central part of the Eastern Ghats. SLWLS covers 464 km² located between 14°45' to 14°72' N & 79°07' to 78°80' E (Map 2.2). The sanctuary ranges from about 137 to 784 m above mean sea level in elevation. The study area was bordered in the west by dense scrub and dry red sanders-bearing forest as well as southern dry mixed deciduous forests on the higher elevations of the Lankamallai hills. To the east, agricultural fields, orchards and croplands are found in the valleys of the semi-perennial river Sagileru. This tributary joins the Pennar river, which borders the southern part as well as a part of western side of the Sanctuary.

2.3.2 Vegetation

The forest type in the main study area is defined as southern tropical thorn scrub (Champion & Seth 1968). Major vegetation in the scrub forest consist of *Acacia* spp., *Zizyphus rugosa* and *Carissa carandas*, and the major tree species were *Hardwickia binata* and

Map 2.2 Location of the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries in Cuddapah and Nellore Districts Andhra Pradesh, India. Map not to scale.

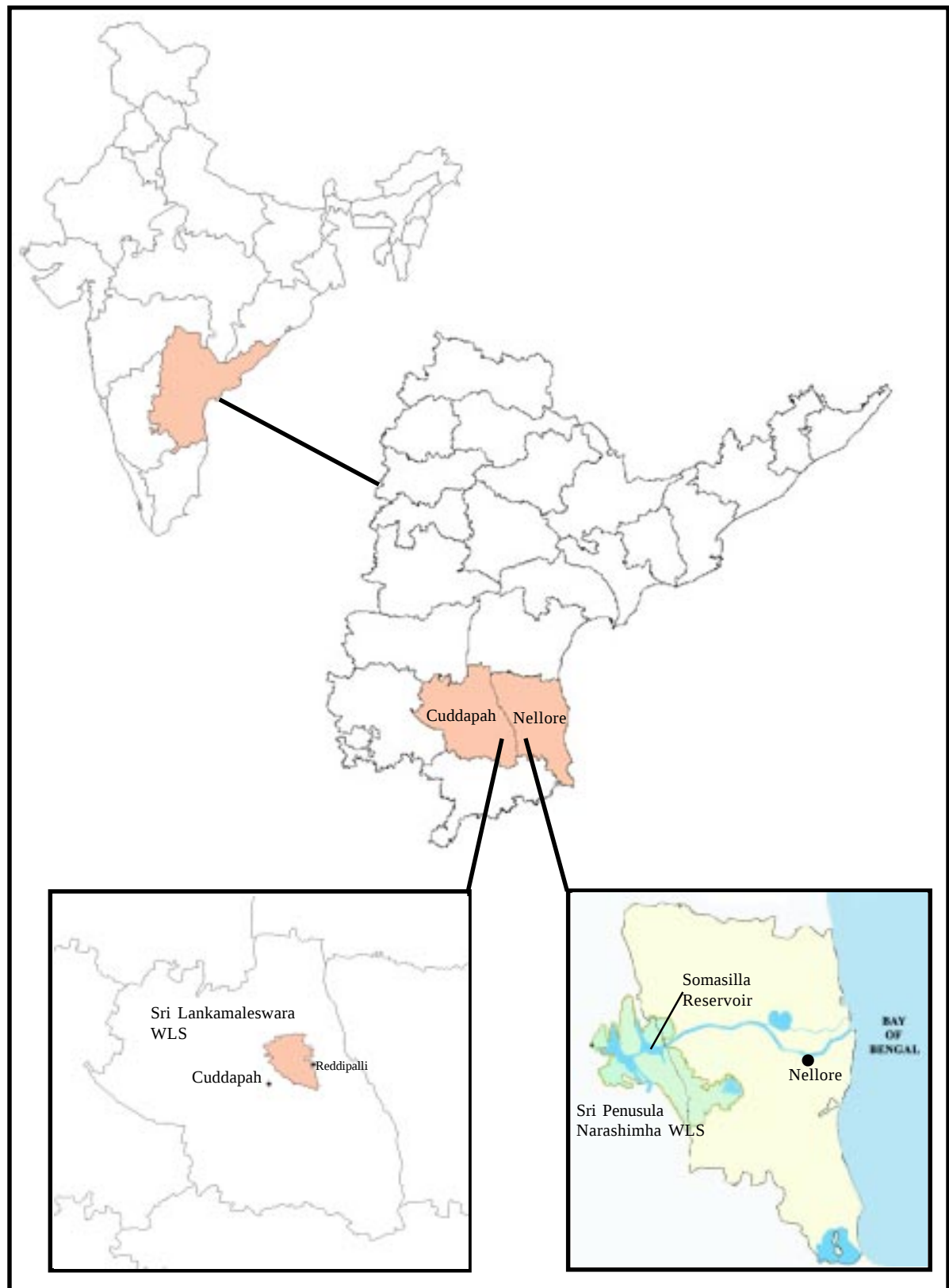


Figure 2.1 Mean monthly minimum and maximum temprature recorded at Cuddapah District from 2001-04.

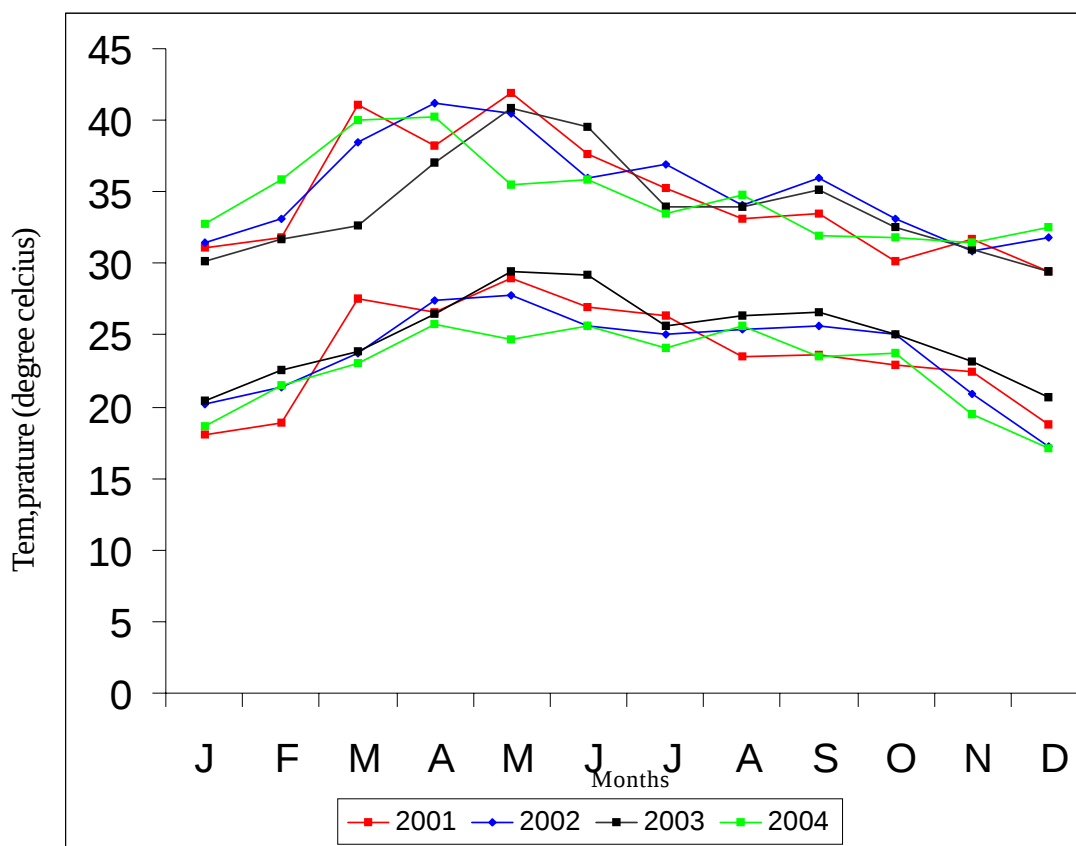
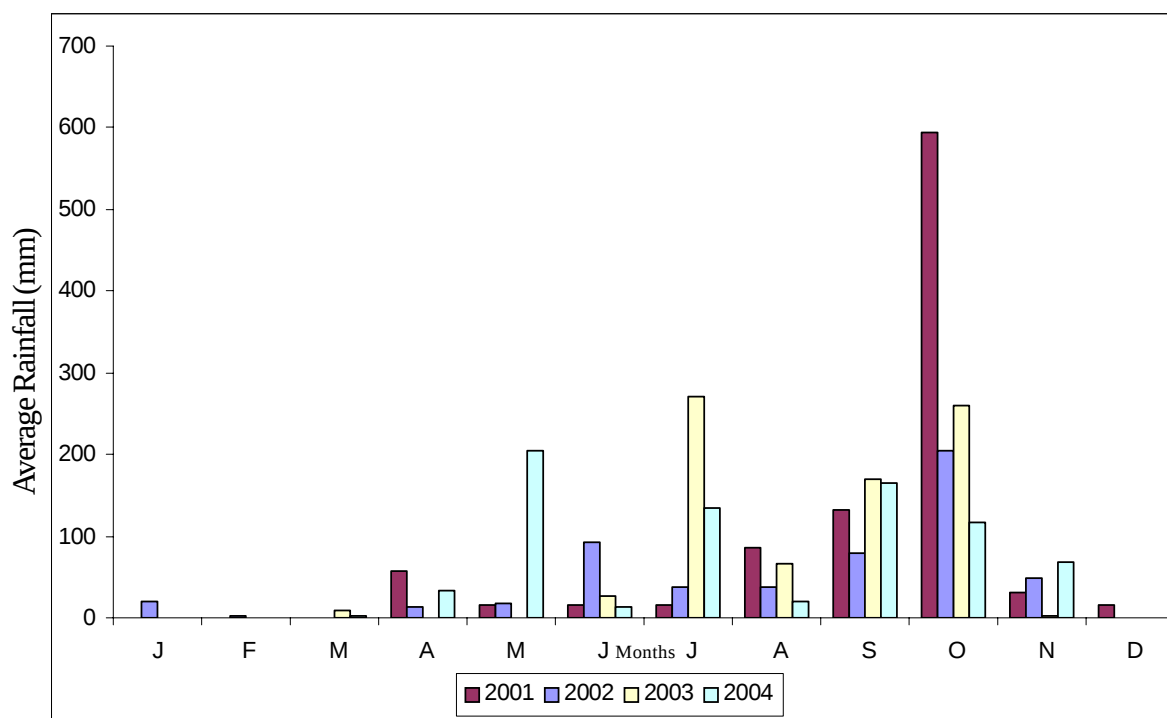


Figure 2.2 Average rainfall recorded in three stations (Badvel, Atlur & Siddavattam) in Cuddapah District from 2001-04.



(Data courtesy: Meteorological Centre, Hyderabad, Andhra Pradesh)

Anogeissus latifolia. Scrub jungle is followed by dry mixed deciduous and Red sanders bearing forest consisting of *Pterocarpus santalinus*, *Terminalia chebula* and *T. tomentosa*. Patches of Dry savannah forest consists of *Anogeissus latifolia* and *Phyllanthus emblica*. Lemon grass *Cymbopogon* spp., is the predominant grass in this open savannah habitat.

The scrub zone in the study area is traversed from west to east by streams that run during the monsoon season and dry up during the rest of the year. Corridors of dense scrub and trees were found along the margins of these streams, with a mixture of open areas and scrub. The substrate consisted of alluvial soil, gravel or stones. The ground vegetation was sparse and dominated by grasses, which dry up during the dry season.

2.3.3 Climate

Generally hot climate prevails throughout the year in the study area. Temperature recorded in Cuddapah from 2001 to 2004 shows that mean monthly daytime temperature ranges between 17.1 °C in December and 41.9 °C in May (Figure 2.1). Four seasons recognized in the study area (a) winter (January-February), (b) summer (March-May), (c) southwest monsoon (June-September) and (d) northeast monsoon (October-December). Study area is influenced by both the southwest and northeast monsoons.

Cuddapah is one of the drought prone districts of Andhra Pradesh and average rainfall for 50 years (1901-1950) is 743.8 mm (Jagannadha Sarma 2002). Rainfall data collected from 2001 to 2004 in three stations (Badvel, Atlur, Siddavattam), which are situated around the SLWLS shows that highest rainfall recorded was 2,888 mm in 2001 and the lowest was 1,785 mm in 2002 (Figure 2.2). In four-year period lowest relative humidity 25% was recorded during March 2001 and the highest 84% was during December 2003.

2.3.4 Fauna

Fauna of the Sri Lankamaleswara Wildlife Sanctuary is not very well documented. Twenty-three species of mammals were recorded during this study including Leopard *Panthera pardus*,

Wolf *Canis lupus*, Dhole *Cuon alpinus*, Sloth bear *Melurus ursinus*, Nilgai *Boselaphus tragocamelus* and Four-horned antelope *Tetracerus quadricornis*. Ghorpade (2004) reports 258 species of birds from the entire Cuddapah district. Two hundred and seven birds species were recorded during this study mainly in and around the sanctuary. This includes the waterbirds recorded from the nearby tanks present outside the sanctuary limits. About 120 bird species were found throughout the year, out of which 45 species were confirmed breeding in the study area. So far, no work has been conducted in this sanctuary to document the lower vertebrate and invertebrates. During this study, 25 species of reptiles and amphibians were recorded including 14 snakes species.

2.3.5 Management, people, and land-use

After the rediscovery of the Jerdon's Courser in 1986, the place where it was rediscovered was officially declared as Sri Lankamaleswara Wildlife Sanctuary in 1988 (Bhushan 1986). Construction of the Somasilla dam, which is in the eastern part of the SLWLS submerged considerable amount of forest area as well as 57 villages were displaced. These settlers were relocated nearby the sanctuary (Bhushan 1995). There are 18 villages situated within 5-10 km of the eastern border of the SLWLS. The forests of the Lankamalai Hill ranges is heavily used by the villagers settled in Sagileru river valley for grazing domestic Buffalo *Bubalus bubalis*, Sheep *Ovis aries* and Goats *Capra hircus* and for cutting wood. The nomadic shepherds stay with their sheep inside the sanctuary for grazing most of the year except during the dry season. The major religious enclave present inside the Sanctuary is the Sri Lankamaleswara Temple. It attracts more than 1000 people every day from the surrounding villages during the weeklong festival held in February. Constructing check dams, percolation pond and trenches are some of the forestry practices in this sanctuary. Apart from that, several hectares of scrub jungle habitat found mainly outside the Sanctuary has been modified into monoculture plantations such as *Terminalia arjuna*, and *Eucalyptus* sp. Major land use around the Sanctuary is agriculture, especially paddy, cotton, groundnut and sunflower and in recent times lemon farming. The only indigenous tribal people found here is Yanadi, but there is no settlement inside the sanctuary.

2.4 Sri Penusila Narasimha Wildlife Sanctuary

2.4.1 Location and extent

Sri Penusila Narasimha Wildlife Sanctuary (SPNWLS) spreads over in the districts of Cuddapah and Nellore, Andhra Pradesh ($14^{\circ}18'$ to $14^{\circ}41'$ N and $79^{\circ}05'$ to $79^{\circ}37'$ E) (Fig.2.5). SPNWLS is adjacent to the Sri Lankamaleswara Wildlife Sanctuary region. This area encompasses Turupukonda hills, part of Velikonda hill ranges, Somasila Dam and Kandaleru reservoir. SPNWLS is divided from the SLWLS by river Sagileru. Study was conducted mainly in the western slope of the Turupukonda hills for about 6 months in the scrub jungle habitat. This place is accessible from the eastern part of the SLWLS and falls under Cuddapah district. Apart from that, a few visits were made to specific sites in Nellore part of the Sanctuary.

2.4.2 Climate, vegetation, and fauna

The climate of the SPNWLS is similar to the SLWLS region. There is not much difference in the vegetation and forest types from that of SLWLS at least in the western part this Sanctuary. Moist deciduous forest and dry thorn forest present at the foothills of Velikonda hill ranges. Fauna of the SPNWLS is poorly documented. So far no detail work on any group of animals is carried out in this Sanctuary. Nevertheless, 14 species of mammals and 118 bird species were recorded during this study from this Sanctuary. Of the 118, birds 68 species were recorded from the Nellore part of the Sanctuary including the Yellow-thoated bulbul *Pycnonotus xantholaemus*, which is restricted to Southern Deccan plateau (BirdLife International 2001).

2.4.3 Management, people and land-use

The total area of 1031 sq. km was declared as a sanctuary on 4th October 1997 by the Andhra Pradesh Forest Department. Main reason to notify this area as a sanctuary is the report of the presence of the critically endangered Jerdon's Courser from the foothills of Turupukonda (Bhushan 1995). Soon after the rediscovery of the Jerdon's Courser in 1986 and after few sightings, this place was proposed as Velikonda Wildlife Sanctuary but it was declared as a sanctuary only after about ten years as Sri Penusila Narasimha Wildlife Sanctuary. Out of total 1031 sq. km sanctuary area, Somasila dam and Kandeleru reservoir spread over 346 sq. km.

To store the water from river Krishna through Telugu-Ganga canals, Somasila dam was constructed in late 1980s, which has submerged about 21% of land cover, which falls inside the sanctuary. Between 1985 and 1997, construction of Somasila dam and Kandeleru reservoir resulted in submerging about 346 sq. km i.e. 33.5% of land cover present inside the sanctuary area. The religious enclave present inside the sanctuary is Sri Peninsula Narasimha Swamy Temple. This place attracts 50 to 100 people per day. Every year, during May, it attracts huge number of people for five-day festival. Major land use is lemon farming and agriculture especially paddy, cotton, groundnut, tobacco and sunflower. Fishing also takes place in the reservoir.

Chapter 3

Development and assessment of new technique for censusing the Jerdon's Courser

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3.1 Introduction

Ecological censuses are carried out mainly to determine the importance of a site, to estimate the population size of an organism, to know the habitat requirements of the species, to monitor the population changes and for habitat management (Sutherland 1996). It is imperative to choose an appropriate method for censusing the target species (Bibby *et al* 2000). A systematic survey for gathering baseline information on the Jerdon's Courser's geographical distribution would be a valuable contribution to assessing its conservation needs (Birdlife International 2001). But the Jerdon's Courser is difficult to study because it is active nocturnally, and the wooded nature of its habitat, together with its retiring habits, makes visual searches in daylight unproductive. Conventionally, records of Jerdon's Coursers have mainly been obtained visually during night-time walks in lightly wooded scrub jungle in which the observer scans the ground within a few metres with the aid of a torch. The effect of disturbance by the observer's footfalls is reduced by the use of a buzzer (Bhushan 1986a).

During the present study, surveys conducted by the conventional method, mentioned above, could detect the Jerdon's Courser only twice in 20 hours of search. These searches were made in the area where sightings were more frequent. This method has several limitations. It is time-consuming, the efficiency is unknown, interpretation of negative results is problematical and it is difficult to follow this method for large-scale surveys to find the Jerdon's Coursers in new localities. Apart from these, the assessment of habitat preferences by such survey may also be unreliable because the methods efficacy seems likely to vary with habitat characteristics, such as the density of bushes and the nature of ground vegetation.

Since it is not possible to follow the night-search method in a large-scale survey, the tracking strip method was developed, that retains the imprints of the feet of animals that walk over them. This survey method was used to know the distribution of Jerdon's Courser. Identifying the animals through their tracks is an age-old technique to confirm their presence in an area (Bider 1968). According to Stander *et al* (1997), tracking (identification, following and interpretation of sign such as footprints, feeding signs and scats) has been one of the fundamental skills shaping

human evolution. However, most of the works based on the identification of tracks are confined to mammals. Well-known examples are Tigers *Panthera tigris* in India (Panwar 1979, Sharma 2003), Snow leopard *Panthera uncia* in Nepal (Ahlborn & Jackson 1988), Mountain lions *Felis concolor* in USA (Smallwood & Fitzhugh 1995, Grigione 1999), African carnivore species, such as African lions *Panthera leo*, leopards *Panthera pardus* and cheetahs *Acinonyx jubatus* (Stander *et al.* 1997), Black rhino *Diceros bicornis* in Africa (Jewell *et al.* 2001) and several small carnivores such as martens, fishers, civets and lesser cats around the world (Taylor & Raphael 1988, Zielinski & Truex 1995, Zalewski 1999, Mukerjee 2000, Mudappa 2001).

Bibby *et al.* (2000) suggest that indirect count of droppings or other signs of birds provide a method for counting some species without observing them. As far as the birds are concerned except for the Houbara bustard *Chlamydotis undulata macqueenii* no other bird species were studied exclusively through tracking. Locating the individuals and nests, feeding behaviour, differentiating the sex and habitat use are the aspects studied through looking at the tracks of the Houbara bustard in United Arab Emirates and Central Saudi Arabia (Gaucher 1991, Launay *et al.* 1996, Maloney 1998, 2001). These studies were based on the tracks retained in the silt, sand or fine gravel under natural conditions. But in my study area since the ground cover in the scrub jungle habitat is mostly of stones and gravel, finding tracks of the Jerdon's Courser were difficult, therefore tracking strips were used for retaining the tracks of the birds. To confirm the species identity, Trailmaster automatic cameras were placed in areas where tracking indicated that the Jerdon's Courser was present.

Automatic camera system is a reliable, versatile and durable tool for remote monitoring of wildlife (Kuchra & Barrett, 1993). It has been used worldwide to study different animal groups on several aspects (Cutler & Swann 1999). Seydack (1984), studied the larger rain forest mammals of Africa, Mace *et al.*, (1994) estimated grizzly bear *Ursus arctos* population size in North America, and Karanth (1995) estimated population density of Tigers and recognized the individual tigers by marks, through photo trapping.

The automatic camera system has been used to illustrate the activity patterns of rainforest mammals on the ground in Indonesia (van Schaik & Griffiths 1996) and in Malaysia (Miura *et al.* 1997). Mudappa (1998) surveyed the status of smaller carnivores in the rainforests of Western Ghats in India, Koerth & Kroll (2000) used camera trapping to determine commonly attracted baits of White-tailed deer *Odocoileus virginianus* and also estimated the sex and age ratios. It was also employed to reveal the fig foraging frequency of primary seed dispersers in Japan (Otani 2001), and to estimate Black bear *Ursus americanus* populations in USA (Martorello *et al.* 2001). Silveira *et al* (2003) used the automatic cameras for conducting rapid faunal assessments in Brazil, Wallace *et al* (2003), Maffei *et al* (2004) and Silver *et al* (2004) for studying Jaguar (*Panthera onca*), Srbeek-Araujo & Chiarello, (2005) for mammal inventory in neo-tropical forests, Gonzalez-Esteban *et al* (2004) for surveying the European mink (*Mustela lutreola*) and Numata *et al* (2005) to determine the mammal species found in Malaysia. Therefore, camera-trapping provide an important non-invasive tool for several aspects of wildlife research. In my study camera trapping was used mainly to confirm presence of the Jerdon's Courser as well as the identity of the animal, which leaves the footprint in the tracking strip.

3.2 Study area

The study was conducted in the scrub jungle in the Sri Lankamalleswara Wildlife Sanctuary, near Reddipalle, Cuddapah District, Andhra Pradesh and on open cropland and pastures outside the Sanctuary. Automatic cameras and tracking strips were placed in two areas of lightly wooded jungle, surrounded by denser scrub, where Jerdon's Coursers had previously been seen. The two patches called JC1 and JC2 were 1.5 ha and 2.0 ha in area respectively and were 80 metres apart at their nearest. Tracking strips were also placed in other habitats outside the reserve to obtain the footprints of various other bird species.

3.3 Methods

3.3.1 Tracking strips

Fine loose soil was obtained from the roadside near by the Sanctuary and passed through a 1 mm sieve. The soil was sieved so that most particles were <0.2 mm in diameter. Soil and sand with larger particles do not retain clear imprints, especially when dry. A strip of ground 5 m long

and 25 cm wide was cleared of stones and its sparse covering of dried-out grasses. The sieved soil was spread along the strip, flattened into a layer 1–2 cm thick, slightly compacted and then smoothed with a builder's trowel. Each strip required c. 25 kg of soil. A thin layer of soil, collected adjacent to the strip, was dusted onto the surface with a sieve to camouflage the difference in color that might otherwise cause birds to avoid the strip.

Tracking strips were placed in the two areas where Jerdon's Coursers had been seen (ten in JC1 and eight in JC2) between 30 January and 7 March 2001. A distance of 24 - 72 metres was left between each strip and its nearest neighbour. The positions of strips were recorded using a Global Positioning System (Garmin GPS III) to aid relocation.

3.3.2 Measurement of Museum skins

Initially, a list of bird species occurring in and around the known Jerdon's Courser habitat was compiled after surveying literature and by direct observations mainly to assess the possibility of other species that may have footprints that could be confused with those of Jerdon's Courser. Since the Jerdon's Courser lacks a hind toe, all species with a hind toe were eliminated. Then measurements of the length of the central toe from museum skins were used to eliminate species whose footprints would be too small or too large to be confused with those of Jerdon's Courser. Two skins of Jerdon's Coursers were examined, one in the University Museum of Zoology, Cambridge, UK and one at the museum of the Bombay Natural History Society in Mumbai, India.

3.3.3 Checking of tracking strips and recording of footprints

Tracking strips were checked at intervals of between one and four days, but usually on alternate days. Each tracking strips were monitored for a total period of 27-54 days from 30 January to 8 April 2001. Simulated bird footprints remained in good condition for at least eight days provided there was no rain. Tracks of birds were recorded and photographs and/or plaster of paris casts were taken of samples of those, which were close to the size expected for Jerdon's Courser. Each visit to a strip on which the tracks of a particular species were recorded is termed a tracking event, regardless of the number of footprints or their distribution on the strip. If wind,

rainfall, humans or livestock had disturbed a greater part of the strip, the period between such a visit and the previous one was excluded from the analysis. After each visit, the surface of a strip was smoothened.

Tracking strips were also placed to obtain the footprints of the other cursorial bird species such as the Indian Courser, Red-wattled Lapwing (*Vanellus indicus*), Yellow-wattled Lapwing (*Vanellus malabaricus*), Painted Sandgrouse (*Pterocles indicus*), Chestnut-bellied Sandgrouse (*Pterocles exustus*), Quail spp., and other Galliformes, which may have footprints similar to the Jerdon's Courser. This was achieved by looking for a field much frequented by that particular species and placing the strip there and also by baiting the granivorous birds with grains. Automatic cameras were also used to identify the species leaving footprints at some of these sites.

3.3.4 Measurement of footprints

Footprints were measured on plaster casts and on photographs. Straight lines running along the central long axis of the imprints of each of the three toes were marked on the cast or photograph and the distances between the intersection of these lines at the hind margin of the foot (B) and points at the tips of the outer (O), central (C) and inner (I) toes were measured with Vernier Callipers to give distances BO, BC, BI respectively. For photographs, the distances were calibrated by a measuring scale marked in mm that was included in the photograph. The intersection point B coincides approximately with the hind margin of the foot. Using the intersection rather than the hind margin itself, allowed the measurement of footprints of running birds, which often do not leave a full imprint of the hind part of the foot. The distances between the tips of the outer and central (OC) and inner and central (IC) toes were also measured. The angle between the long axes of the outer and central toes was then calculated as,

$$\arccos ((BC^2 + BO^2 - OC^2) / (2 * BC * BO))$$

and the equivalent angle for the inner and central toes as,

$$\arccos ((BC^2 + BI^2 - IC^2) / (2 * BC * BI))$$

The angle between the outer and inner toes was the sum of these two angles. If there were measurements of more than one footprint from a given tracking event, means of those measurements were used in further analyses.

3.3.5 Statistical analysis

SPSS software (Version 10.0.1) was used for statistical analyses. Stepwise discriminant function analysis was used to differentiate the Jerdon's Courser footprint from other bird species based on the measurements taken from the tracks, and also to know, which are the parameters most useful in differentiating one bird species to another. The multivariate method was used for identifying individual Black rhino population based on their spoor or tracks (Jewell *et al* 2001), for discriminating the sex of the Pine Martens *Martes martes* and tigers using their tracks (Zalewski 1999, Sharma *et al* 2003), for distinguishing the track of American marten *M. Americana* and Fisher *M. pennanti* (Zielinski & Truex 1995) and also it has been widely used to determine the sex in adults of several bird species with monomorphic plumage (Martin *et al* 2000). Seven variables, namely length of central (C), inner (I), outer (O) toes, angle between central and outer (AOC), central and inner toes (AIC), ratio of central to outer toe (ROC) and ratio of central to inner toe (RIC) are taken from the tracks of seven species in this analysis. An F statistic based on the one-way test of analysis of variance is used in the selection of the variables. Values of $F = 3.84$ and $F = 2.71$ were used to enter and remove variables in a forward manner. For cross-validation of the classification results, "Jack-Knife estimate" or "leave-one-out estimate" or "hold out procedure" method (Lachenbruch & Mickey, 1968) was used.

3.3.6 Automatic cameras

To confirm the presence as well as the footprint of the Jerdon's Courser, eight Trailmaster camera kits (Goodson & Associates Inc., 10614 Widmer, Lenexa KS 66215, USA) were used, each of which consisted of a TM1500 infra-red transmitter and receiver/logger, a TM35-1 camera and connecting cable. Cameras were deployed at fifteen sites (eight in JC1 and seven in JC2) between 29 January and 15 February 2001. At each site, a 5-6 m long strip was monitored. Many of the sites coincided with tracking strips, with the kit being set up to photograph animals which crossed the strip. Since the study area was used by people during the daytime for the collection of wood and grazing of buffalo so it was necessary to protect the equipment from interference or removal by humans or animals, by deploying it at dusk and removing it at dawn. The transmitting

and receiving units were placed on the ground so that they monitored a strip about 5 metres long. The camera was also fixed at the same end of the strip as the receiver. This was done to avoid taking multiple pictures of the same individual.

The locations of cameras were stored in the memory of a GPS, which allowed them to be relocated without the use of visible markers. The receiver units were programmed only to trigger the camera between dusk (18.30) and dawn (06.30) and only to trigger if the beam was broken for at least 0.05 seconds. After triggering a photograph, the unit was programmed not to take another photograph if the beam was broken again within one minute. This was done to avoid taking multiple pictures of the same individual.

3.4 Results

3.4.1 Automatic cameras

Excluding nights on which the triggering devices malfunctioned because of inaccurate beam alignment, the cameras were in operation for a total of 42 camera-nights (22 in JC1 and 20 in JC2). Four photographs of birds were obtained, two of Jerdon's Courser (at two sites in JC1), one of Stone Curlew and one of Red-wattled Lapwing. Therefore, the estimated probability per camera-night of obtaining a photograph of Jerdon's Courser in the two areas combined was $2/42 = 0.0476$. The exact binomial 95% confidence limits (Diem 1962) of this estimate were 0.0060 to 0.1616. Stone Curlews and Red-wattled Lapwings were also seen in both of these areas and their calls were also frequently heard. No other charadriiform species were seen on the ground in these two areas.

3.4.2 Identification of footprints on tracking strips

The central toe lengths (BC) of two museum specimens of Jerdon's Courser were 28.0 and 26.3 mm. Diagnostic methods were developed to distinguish footprints from those of other species with mean central toe lengths of 20–40 mm, which were Painted Sandgrouse, Chestnut-bellied Sandgrouse, Indian Courser, Yellow-wattled Lapwing, Red-wattled Lapwing, Stone Curlew and Barred Buttonquail *Turnix suscitator*. For most of these species it was able to restrict further diagnostic analysis by taking measurements of toe lengths from casts and photographs of footprints of known origin made on tracking strips (Table 3.1).

Table 3.1. Means of linear measurements (mm), toe length ratios and angles between toes (degrees) for Jerdon's Courser and other cursorial birds. Sample size (*n*) is the number of tracking events. Means were taken where more than one footprint was measured from the same tracking event.

SPECIES	Central toe		Outer toe		Inner toe		Ratio O:C		Ratio I:C		Angle O-C		Angle I-C		Angle O-I		<i>n</i>
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Jerdon's Courser ¹	29.4	-	19	-	16.4	-	0.646	-	0.558	-	35.9	-	39.8	-	75.7	-	1
Jerdon's Courser ²	-	-	-	-	-	-	0.657	-	0.604	-	40.1	-	40.2	-	80.3	-	1
Jerdon's Courser ³	28.43	1.89	20.36	2.47	18.13	1.37	0.719	0.091	0.639	0.037	36.1	3.6	40.1	5.0	76.3	6.9	26
Stone Curlew	40.53	2.38	30.78	2.27	25.97	2.69	0.760	0.044	0.640	0.047	30.2	6.2	25.6	2.5	55.9	6.9	17
Red-wattled Lapwing	37.72	1.02	29.05	0.91	24.15	1.18	0.771	0.034	0.641	0.033	48.7	5.1	50.8	7.0	99.5	9.2	17
Indian Courser	28.71	1.93	16.86	1.66	14.56	1.73	0.587	0.033	0.506	0.041	43.5	7.5	52.4	7.6	96.0	4.6	18
Chestnut-bellied Sandgrouse	28.32	2.70	20.70	1.77	17.20	1.39	0.733	0.038	0.609	0.028	47.1	6.7	51.6	4.8	98.8	9.6	16
Yellow-wattled Lapwing	25.31	1.86	18.97	1.03	17.41	1.30	0.752	0.041	0.690	0.051	43.3	5.6	39.6	4.5	83.0	7.5	16
Barred Buttonquail	22.67	1.02	18.15	1.18	14.17	0.96	0.800	0.024	0.625	0.018	42.6	0.2	44.3	1.6	86.9	1.6	12

¹ from a 35 mm transparency of a two footprints made by a Jerdon's Courser photographed crossing a tracking strip on 14 February 2001.

² from a colour print photograph of two footprints made by a Jerdon's Courser photographed crossing a tracking strip on 14 February 2001. A scale was not present in this photograph, so absolute measurements of toe length could not be calculated.

³ from plaster casts, 35 mm slides and photographs of tracking events attributed to Jerdon's Courser on the basis of resemblance to the events labeled 1 and 2 in this Table.

Table 3.2. Means of linear measurements (mm), toe length ratios and angles between toes (degrees) for partially grown cursorial birds. Sample size (n) is the number of tracking events. Means were taken where more than one footprint was measured from the same tracking event.

SPECIES	Central toe		Outer toe		Inner toe		Ratio O:C		Ratio I:C		Angle O-C		Angle I-C		Angle O-I		n
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Jerdon's Courser ¹	22.40	-	17.90	-	15.03	-	0.799	-	0.671	-	30.8	-	34.8	-	65.6	-	1
Stone Curlew ²	22.04	0.79	17.39	0.08	15.11	0.32	0.790	0.032	0.686	0.010	39.2	1.52	29.7	0.5	68.9	2.1	2
Red-wattled Lapwing ³	28.98	-	22.24	-	19.39	-	0.768	-	0.669	-	59.3	-	49.2	-	108.5	-	1
Yellow-wattled Lapwing ⁴	20.60	-	18.30	-	15.25	-	0.888	-	0.741	-	47.2	-	45.6	-	92.8	-	1
Chestnut-bellied Sandgrouse ⁵	15.70	-	12.10	-	11.30	-	0.771	-	0.720	-	38.1	-	41.4	-	79.5	-	1

¹ & ⁵ from plaster cast of the footprint made by the partially grown bird tracks found along with the adult bird tracks in the same tracking strip.

^{2, 3} & ⁴ from the photographs and plaster cast of the footprint made by the partially grown birds seen while crossing the tracking strips.

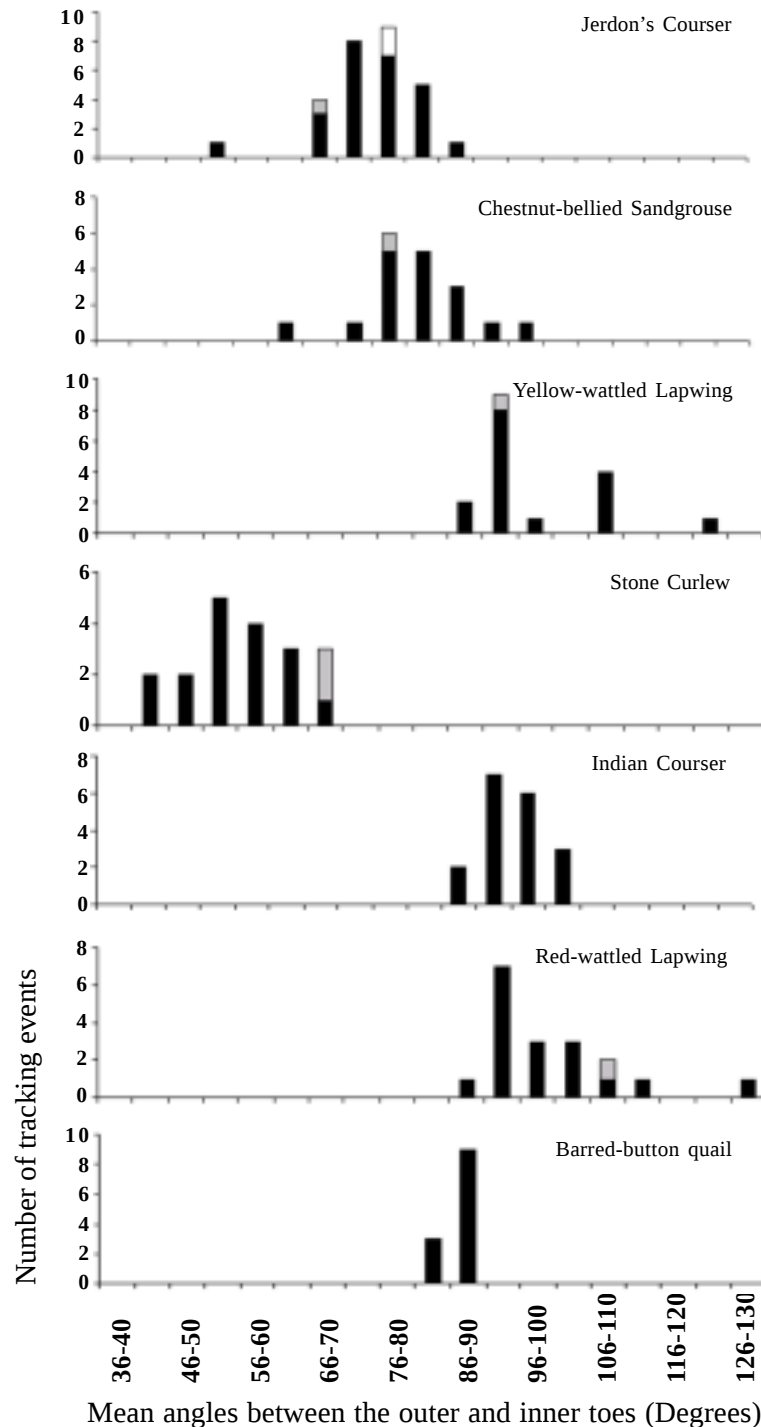
Footprints of Barred Buttonquail were smaller and the angle between the outer and inner toes (Angle O-I) was larger than those of Jerdon's Courser. Toe lengths of the Stone Curlew and Red-wattled Lapwing were larger and the Angle O-I in the Stone Curlew was smaller and in the case of Red-wattled Lapwing it was larger than that of the Jerdon's Courser (Figure 3.1, Table 3.1). The central toe lengths of full-grown birds of these species are likely to overlap those of Jerdon's Courser only rarely. The outer and inner toes of Indian Courser also tends to be shorter, relative to the central toe, than those of Jerdon's Courser and the Angle O-I is larger (Table 3.1).

In the case of Yellow-wattled Lapwing though the Angle O-I was larger than the Jerdon's Courser, there is some overlap in the toe lengths between these two species. Furthermore there is a small over lap in the Angle O-I and the outer and inner toes of the Chestnut-bellied Sandgrouse and the Jerdon's Courser. There is a possibility that tracks of these two species could be confused with the tracks of the Jerdon's Courser but it can be overcome by looking at the specific characters in their footprints, which are distinguishable from each other (see Discriminant Analysis).

Most tracks of Jerdon's Courser can be distinguished from those of other species on the basis of size, the length of the toes relative to one another, and the angle between the outer and inner toes. The last character alone is likely to be sufficient to distinguish tracks made by partly-grown precocial young of Stone Curlew, Red-wattled Lapwing, Yellow-wattled Lapwing and Chestnut-bellied Sandgrouse, from those of full-grown Jerdon's Coursers, even when they are not distinguishable by size.

Plaster casts and photographs of footprints from few tracking events, (Table 3.2 of a partly grown birds of Jerdon's Courser, Stone Curlew, Red-wattled Lapwing, Yellow-wattled Lapwing and Chestnut-bellied Sandgrouse, was obtained. The mean length of the central toe was, much less than that of full-grown birds of the same species (Table 3.1). However the mean angle between the outer and inner toes was well within the range for full-grown birds (Figure 3.1). So it is possible to ascertain the identity of the footprint of the partially grown birds by measuring the mean angle between the outer and inner toes.

Figure 3.1. Frequency distributions of mean angles between the outer and inner toes from plaster casts and photographs of footprints of seven bird species, in 5degree bins. For Jerdon's Courser, two tracking events for which the species identity was confirmed by automatic camera photographs are shown separately (white bar) from the events classified as Jerdon's Courser by resemblance to the confirmed tracks (black bars). Grey bars indicate the angles of the partially grown birds. Mean of the measurements are given in Table 3.2.



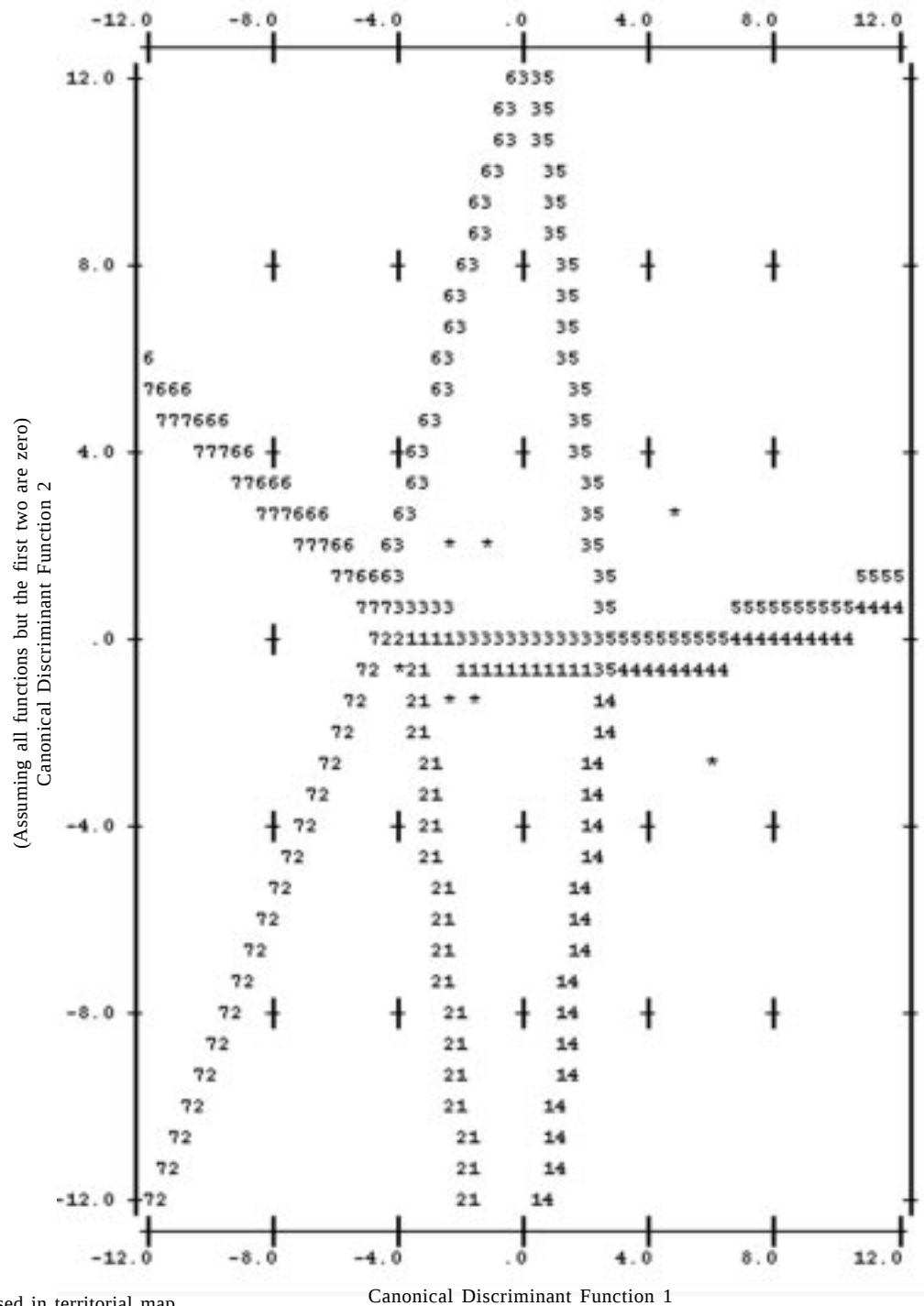
3.4.3 Discriminant analysis

Stepwise discriminant function analysis (DFA) was performed on the data from the seven bird species listed in the Table 3.1. These seven species were discriminated with 94.3% accuracy in original classification method and the leave-one-out (Jackknife) estimator classified them with 91.9% accuracy. (Figure 3.2, Figure 3.3, Table 3.3). In this analysis 5 of 7 variables, which are listed in Table 3.4 were selected to discriminate between the bird species. Outer toe, central toe and inner toe lengths characterized the first discriminant function. (Table 3.4 & 3.5).

In the cross-validated results, 7.4% Jerdon's Courser tracks overlapped with Chestnut-bellied Sandgrouse tracks. A small amount of Jerdon's Courser tracks (3.7%) was misclassified as Barred Buttonquail track. Similarly 6.3% Chestnut-bellied Sandgrouse tracks were overlapped with the Jerdon's Courser, Yellow-wattled Lapwing and Barred Buttonquail tracks. Also there was 6.3% overlap between Yellow-wattled Lapwing tracks and the Jerdon's Courser as well as the Barred Buttonquail tracks. Stone Curlew, Red-wattled Lapwing and Barred Buttonquail tracks were discriminated completely without any misclassification. Cross-validation results also show that these three bird tracks were classified with 100% accuracy. Indian Courser tracks were classified with 94.4% accuracy and overlapped 5.6% with Yellow-wattled Lapwing tracks.

All the species which are classified with 100% accuracy with respect to the Jerdon's Courser were eliminated and the stepwise DFA was performed for rest of the bird species. Although Jerdon's Courser overlapped with the Barred Buttonquail track it was not included in this analysis since the overlap was very small (3.7%). Stepwise DFA for Jerdon's Courser, Chestnut-bellied Sandgrouse and the Yellow-wattled Lapwing with seven variables classifies them with an accuracy of 93.2% and the leave-one-out (Jackknife) estimator gave 89.8 % accuracy in classification. (Figure 3.4, Figure 3.5 & Table 3.6). In this analysis all of the seven variables were used to discriminate between these three species. The discriminant function model uses five of these variables to classify these three species with the aforementioned accuracy (Table 3.7).

Figure 3.2 Territorial map for discrimination of 7 bird species based on their footprint measurements, using 7 variables in DFA.



Symbols used in territorial map

Symbol	Group Label	Symbol	Group Label
1	Jerdon's Courser	5	Red-wattled Lapwing
2	Chestnut-bellied Sandgrouse	6	Indian Courser
3	Yellow-wattled Lapwing	7	Barred Buttonquail
4	Stone Curlew	*	Indicates a group centroid

Figure 3.3. Group centroids and footprint clusters of 7 bird species on canonical function axis, using 7 variables in DFA.

JC - Jerdon's Courser, CBSG - Chestnut-bellied Sandgrouse, YWL - Yellow-wattled Lapwing, SC – Stone Curlew, RWL – Red-wattled Lapwing, IC – Indian Courser, BBQ - Barred Buttonquail.

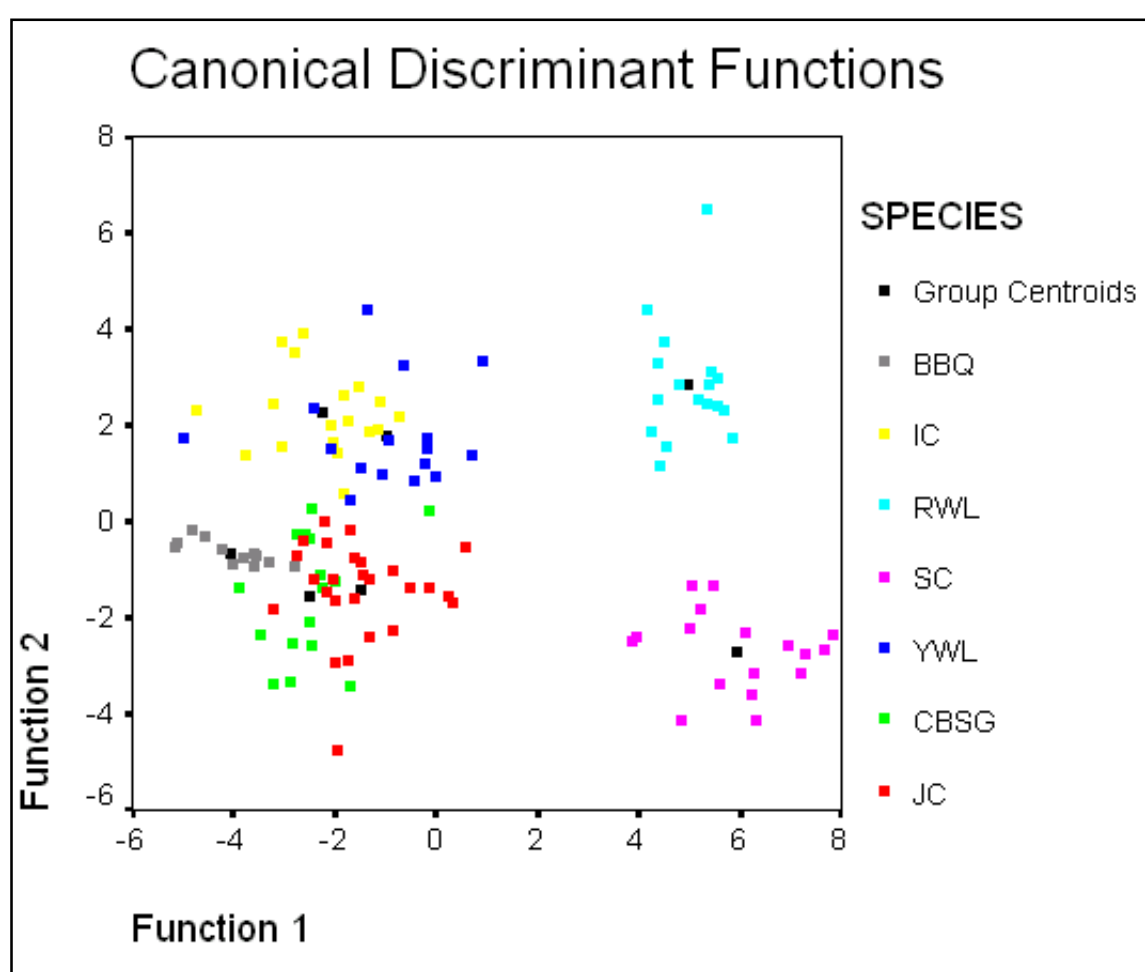


Table 3.3. Classification accuracy matrix for discrimination of 7 bird species based on their track measurements (7 variables are used for DFA).Classification Results ^{b,c}

SPECIES		Predicted Group Membership							Total
		JC	CBSG	YWL	SC	RWL	IC	BBQ	
Original Count									
	JC	25	2	0	0	0	0	0	27
	CBSG	1	13	1	0	0	0	1	16
	YWL	1	0	14	0	0	0	1	16
	SC	0	0	0	17	0	0	0	17
	RWL	0	0	0	0	17	0	0	17
	IC	0	0	0	0	0	18	0	18
	BBQ	0	0	0	0	0	0	12	12
%									
	JC	92.6	7.4	.0	.0	.0	.0	.0	100.0
	CBSG	6.3	81.3	6.3	.0	.0	.0	6.3	100.0
	YWL	6.3	.0	87.5	.0	.0	.0	6.3	100.0
	SC	.0	.0	.0	100.0	.0	.0	.0	100.0
	RWL	.0	.0	.0	.0	100.0	.0	.0	100.0
	IC	.0	.0	.0	.0	.0	100.0	.0	100.0
	BBQ	.0	.0	.0	.0	.0	.0	100.0	100.0
Cross-validated Count									
	JC	24	2	0	0	0	0	1	27
	CBSG	2	12	1	0	0	0	1	16
	YWL	1	0	14	0	0	0	1	16
	SC	0	0	0	17	0	0	0	17
	RWL	0	0	0	0	17	0	0	17
	IC	0	0	1	0	0	17	0	18
	BBQ	0	0	0	0	0	0	12	12
%									
	JC	88.9	7.4	.0	.0	.0	.0	3.7	100.0
	CBSG	12.5	75.0	6.3	.0	.0	.0	6.3	100.0
	YWL	6.3	.0	87.5	.0	.0	.0	6.3	100.0
	SC	.0	.0	.0	100.0	.0	.0	.0	100.0
	RWL	.0	.0	.0	.0	100.0	.0	.0	100.0
	IC	.0	.0	5.6	.0	.0	94.4	.0	100.0
	BBQ	.0	.0	.0	.0	.0	.0	100.0	100.0

a Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

b 94.3% of original grouped cases correctly classified.

c 91.9% of cross-validated grouped cases correctly classified.

Table 3.4 Structure matrix for discrimination of 7 bird species based on 7 variables. Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

	Function					
	1	2	3	4	5	6
O	0.888*	-0.154	0.333	-0.099	0.238	-0.102
C ^a	0.845*	0.019	-0.382	-0.125	0.172	0.233
I	0.703*	-0.234	0.135	0.285	0.450	0.387
AIC	-0.182	0.751*	0.072	0.106	0.557	-0.276
ROC	0.149	-0.251	0.883*	-0.039	0.107	-0.349
RIC	0.084	-0.371	0.563	0.597*	0.361	0.225
AOC	-0.075	0.456	0.282	0.240	-0.689*	0.419

O-Outer toe, C- Central toe, I-Inner toe, AIC-Angle I-C, ROC-Ratio O-C, RIC-Ratio I-C, AOC-Angle O-C

* indicates largest absolute correlation between each variable and any discriminant function. ^a indicate the variable which was not used in the analysis.

Table 3.5 Discrimination function coefficients for discriminating 7 bird species based on their footprint measurement, using 6 variables.

	SPECIES						
	JC	CBSG	YWL	SC	RWL	IC	BBQ
O	1.825	2.787	0.454	9.560	9.559	1.165	-10.647
I	4.471	2.280	7.028	1.648	1.827	5.431	16.769
ROC	317.082	297.599	411.718	190.756	209.046	305.602	762.587
RIC	115.748	208.580	-0.187	160.850	155.70	24.684	-304.601
AOC	2.069	2.252	2.566	2.192	2.922	2.329	2.288
AIC	1.916	1.901	2.388	1.562	2.544	2.365	1.992
(Constant)	-284.723	-318.661	-340.081	-347.611	-429.143	-260.022	-326.996

Fisher's linear discriminant functions

JC - Jerdon's Courser, CBSG - Chestnut-bellied Sandgrouse, YWL - Yellow-wattled Lapwing, SC – Stone Curlew, RWL – Red-wattled Lapwing, IC – Indian Courser, BBQ - Barred Buttonquail.

Figure 3.4 Group centroids and footprint clusters of 3 bird species on canonical function axis, using 7 variables in DFA.

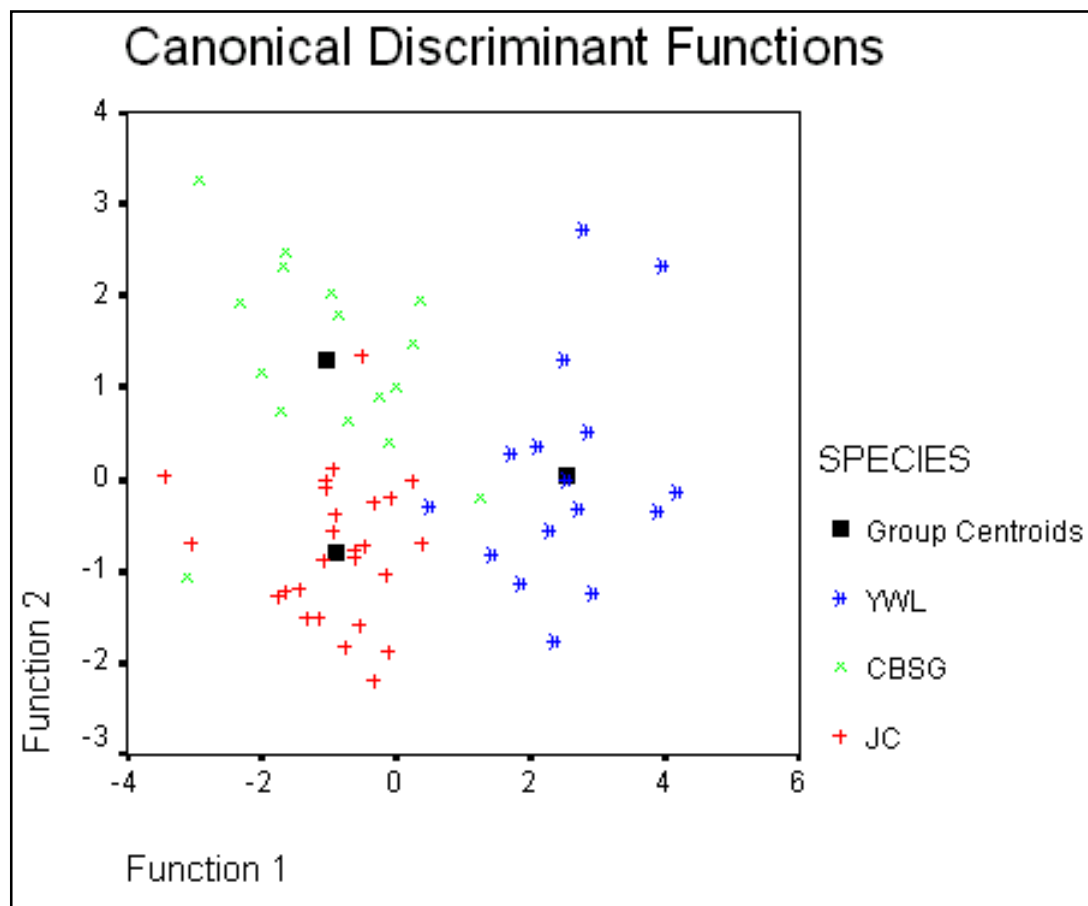


Table 3.6. Classification accuracy matrix for discrimination of 3 bird species based on their track measurements (7 variables are used for DFA).

Classification Results ^{b,c}					
		Predicted Group Membership			
SPECIES		JC	CBSG	YWL	Total
Original Count					
	JC	26	1	0	27
	CBSG	1	14	1	16
	YWL	1	0	15	16
%	JC	96.3	3.7	.0	100.0
	CBSG	6.3	87.5	6.3	100.0
	YWL	6.3	.0	93.8	100.0
Cross-validatedCount					
	JC	25	2	0	27
	CBSG	2	13	1	16
	YWL	1	0	15	16
%	JC	92.6	7.4	.0	100.0
	CBSG	12.5	81.3	6.3	100.0
	YWL	6.3	.0	93.8	100.0

a Cross validation is done only for those cases in the analysis.

In cross validation, each case is classified by the functions derived from all cases other than that case.

b 93.2% of original grouped cases correctly classified.

c 89.8% of cross-validated grouped cases correctly classified.

Table 3.7 Structure matrix for discrimination of 3 bird species based on 7 variables. Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

	Function	
	1	2
AIC	0.700*	-0.005
C ^a	0.149	-0.733*
AOC	0.442	0.674*
RIC	-0.349	0.620*
ROC	0.065	0.514*
O ^a	0.211	-0.329*
I	-0.126	-0.238*

AIC-Angle I-C, C- Central toe, AOC-Angle O-C, RIC-Ratio I-C, ROC-Ratio O-C
O-Outer toe, I-Inner toe

* indicates largest absolute correlation between each variable and any discriminant function.

^a indicates the variable which, was not used in the analysis.

The model developed using five variables for discriminating these three bird species from one another was:

For Jerdon's Courser:

$$JC = 12.893 (I) + 408.914 (ROC) - 11.812 (RIC) + 1.578 (AOC) + 2.791 (AIC) - 342.086$$

For Chestnut-bellied Sandgrouse:

$$CBSG = 12.238(I) + 414.718 (ROC) + 25.162 (RIC) + 1.815 (AOC) + 2.707 (AIC) - 365.286$$

For Yellow-wattled Lapwing:

$$YWL = 13.732(I) + 463.471 (ROC) - 69.672 (RIC) + 1.945 (AOC) + 3.312 (AIC) - 399.237$$

Where,

I = Inner toe, ROC = Ratio O-C, RIC = Ratio I-C, AOC = Angle O-C and AIC = Angle I-C

Examination of the feet of museum skins of Painted and Chestnut-bellied Sandgrouse showed that both had larger pads at the hind margin of the foot than Jerdon's Courser and other Charadriiformes. All the tracks of Chestnut-bellied Sandgrouse, obtained on tracking strips also showed impressions of these pads, which when visible at all on the footprints in two Jerdon's Courser tracking events confirmed by the automatic cameras, were shorter (3–4 mm) than those of the sandgrouse (7–10 mm). Other diagnostic characters in the Chestnut-bellied Sandgrouse tracks are a different position of the junction of toes with the pad and distinctive drag marks from the claw of the central toe. Chestnut-bellied Sandgrouse were often seen in the study areas whereas the Painted Sandgrouse was rarely encountered.

Chances of confusion with Yellow-wattled Lapwing footprints are less since the impression of pads is not very prominent as in the case with Jerdon's Courser tracks. Furthermore, none was seen in the study area even though these lapwings are diurnal and easy to see in their preferred, more open habitat. Hence, the tracks of these three species can probably be separated from those of Jerdon's Courser based on the difference in the angle between the inner and central toe, though further support for this conclusion is needed by adding few more parameters such as size of the pad, width of the toes and from measurements of larger samples of tracks.

3.4.4 Tracking events

Footprints of three charadriiform species, Jerdon's Courser, Stone Curlew and Red-wattled Lapwing were observed on the tracking strips set in the two study areas where Jerdon's Courser had previously been seen (Table 3.8). For the Jerdon's Courser twenty four tracking events were recorded from JC1 and JC2 areas. These two places were monitored for 781 tracking strip nights. So the estimated probability per strip-night of obtaining a tracking event of Jerdon's Courser in the two areas combined was $24/781 = 0.0307$. The exact binomial 95% confidence limits of this estimate were 0.0193 to 0.0429).

Tracking events attributed to Jerdon's Courser were recorded on 11 of the 18 tracking strips, with a maximum of four events occurring on the same strip. Expected probabilities of

Table 3.8 Numbers of tracking events attributed to Jerdon's Courser, Stone Curlew and Red-wattled Lapwing for 18 tracking strips set in two patches of lightly wooded scrub jungle in which Jerdon's Courser was known to occur by direct observations. Monitoring of strips covers the period 31 January to 8 April 2001.

Species	Site	Strip-nights	Tracking events	Events per strip-night
Jerdon's Courser	JC1	420	17	0.04048
	JC 2	361	7	0.01939
	Both	781	24	0.03073
Stone Curlew	JC 1	420	53	0.12619
	JC 2	361	35	0.09695
	Both	781	88	0.11268
Red-wattled Lapwing	JC 1	420	32	0.07619
	JC 2	361	28	0.07756
	Both	781	60	0.07682

observing 0, 1, 2, ..., n tracking events were calculated for each strip by using the Poisson theorem. It was assumed that the expected mean number of tracking events for the strip was the product of the estimated probability of a tracking event per strip-night, calculated over all strips (0.0307), and the number of nights for which the strip was monitored. These probabilities were then summed to give expected numbers of strips at which 0, 1, 2, ..., n tracking events would be observed. The expected numbers of strips with 0, 1, 2, 3, 4 and 5 or more tracking events were 5.07, 6.08, 3.99, 1.88, 0.70 and 0.28 respectively compared with the observed distribution of 7, 5, 1, 3, 2 and 0. The observed and expected distributions are similar and are not significantly different ($\chi^2_{(2)} = 1.03$, $P > 0.25$; strips with two or more tracking events combined to avoid expected cell totals < 5). Hence, the observations are consistent with the hypothesis that the underlying probability of Jerdon's Courser leaving tracks was similar for all the tracking strips in our study areas.

3.5 Discussion

These results shows that the presence of Jerdon's Courser in an area of scrub jungle can be detected both by automatic cameras and by tracking strips and that the probabilities of detecting Jerdon's Courser per night of monitoring with a single camera or a single strip were similar (0.0476 cf. 0.0307 respectively). Therefore, both methods might have applications in the survey of the distribution of the Jerdon's Courser.

Surveys following these two methods would provide firm evidence of not only the presence, but also the absence of the species from a given area during the survey period. Suppose if there is a probability V of being incorrect assuming that the Jerdon's Coursers are not present in a patch of potentially suitable habitat where we have obtained no photographs or tracking events in a survey consisting of K camera-nights or strip-nights of monitoring. Assume also that there is an estimate R of the nightly probability of obtaining a photograph or tracking event in areas where Jerdon's Coursers are present and that this applies equally to all cameras or strips. It can be shown that, under these circumstances, the target error rate V will be obtained if

$$V = (1-R_1) \dots (1-R_2) \dots (1-R_K)$$

$$\text{Since } R_1 = R_2 = \dots = R_K$$

$$V = (1-R) \dots (1-R) \dots (1-R)$$

$$V = (1-R)^K$$

Rearranging this to obtain an expression for K gives,

$$K = \log(V) / \log(1-R).$$

Hence, for a survey to have a 1% chance of being wrong in suggesting that Jerdon's Courser is absent from an area in which no records are obtained and use the estimate of R from the tracking strip survey (0.0307), the required number of camera-nights or strip-nights obtained was

$$K = \log(0.01) / \log(1-0.0307) = 148.$$

Since the value of R is an estimate from limited data and that the true value that might have come close to by carrying out a much larger survey in our study areas might be somewhat lower. Apart from that the estimate of R comes from just two small patches of habitat and is an overestimate since it is based on limited data. It might be possible that the density or activity of Jerdon's Coursers might well be lower in other patches. Therefore it is prudent to use a considerably lower value of R for this calculation. If the value $R = 0.01$ then it gives

$$K = \log(0.01)/\log(1-0.01) = 458.$$

This means that if survey is carried out in an area using more than 458 camera-nights or strip-nights then there would be a chance of 1% or less of being incorrect in taking absence of Jerdon's Courser records to indicate that the species was absent during the survey. This calculation will only be valid if there is a high probability that the home range of any Jerdon's Courser present in a survey area overlaps several camera or tracking strip sites. Hence, the sites should not be spaced too far apart and should be placed on a roughly regular grid. In the absence of any information on the ranging behaviour of Jerdon's Courser it was assumed from experience of other charadriiforms (Green *et al.* 2000) that the spacing of tracking strips used in this study (an average of about 50 m) would be adequate. A practical method for surveying a 5 hectare patch of apparently suitable habitat would therefore be to place 20 cameras or tracking strips on a grid at regular intervals of 50 m and to monitor them for at least 12 nights.

These calculations indicate that it would be difficult to accomplish a large-scale systematic survey of Jerdon's Courser distribution using cameras alone. Not only are the camera kits quite expensive, but also in areas frequently visited by people it would probably be necessary to remove and re-deploy the equipment at dawn and dusk every day. So a more practical procedure would be to use tracking strips for the survey. This has several advantages. The material for the strips is freely available. Although the effort to prepare the soil and deploy the strips is considerable, it is similar to that involved in installing cameras. It was found that two people could deploy 8-10 cameras or strips in a day, given that the study area could be approached within up to 100 meters in a vehicle.

The use of tracking strips has the disadvantage that there is a small but definite risk of misidentifying footprints, whereas automatic camera photographs taken at a range of less than 5 metres would almost always allow species to be identified with certainty. To overcome this problem, a large-scale survey should be carried out using tracking strips, but that in any area in which tracking events are attributed to Jerdon's Courser, automatic cameras should be deployed as soon as possible to confirm the identification. So survey using tracking strips offers the best prospect of obtaining accurate information on the range of this species. Tracking strips may also have useful applications in other aspects of the study of Jerdon's Courser, such as the quantification of habitat and microhabitat use and selection.

Chapter 4

Vocalization and calling behavior of the Jerdon's Courser

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4.1. Introduction

The call of the Jerdon's Courser was not known previously, the only published reports on its calls are "a plaintive cry" (Ali & Ripley 1983), "very sad; a single note and very soft" (Bhushan 1990), "not very vocal; plaintive cry: he-he-he-he-he" (Kazmierczak & van Perlo 2000) and "kwick- kweek- kwick- kweek-kweek- kweekkweek", as described by some bird trappers (Samant & Elangovan 1997). The latter description, however, was thought to be more likely to be that of the Stone Curlew *Burhinus oedicephalus* (Samant & Elangovan 1997).

Call recording was carried out because recorded calls can be used in tape playback method to elicit responses of nocturnal and secretive bird species. This method has been followed to gather information on the distribution of Forest Owlet *Athene blewitti* (Ishtiaq & Rahmani 2000), distribution and abundance of the Puerto Rican Nightjar *Caprimulgus noctitherus* (Vilella & Zwank, 1993), to estimate population of Christmas Island Hawk-Owl *Ninox natalis*, (Hill & Lill 1998a), for detecting Burrowing owls *Speotyto cunicularia* (Haug & Didiuk, 1993) and Long-eared Owls *Asio otus* (Martinez *et al.*). This technique has been used to find out the relative abundance and density of Black Rails *Laterallus jamaicensis* (Legare *et al.* 1999), to monitor breeding water birds (Gibbs & Melvin 1993) to detect nests, survey and monitor several diurnal raptor populations (Rosenfield *et al.* 1988; Mosher *et al.* 1990 and Reid *et al.* 1999)

Recorded calls can also be used for individual recognition of birds (Eakle *et al.* 1989; Galeotti *et al.* 1993 and Hill & Lill 1998b). Several studies show that vocal individuality can be used to estimate of individuals and has potential for monitoring the secretive bird species, which are difficult to observe (McGregor & Byle, 1992; Otter, 1996; Peake *et al.* 1998 and Delport *et al.* 2002).

4.2 Study area

Since the Jerdon's Courser is nocturnal, efforts were made right from the beginning of the study to listen for, and record, its calls during dawn and dusk in the places where it was frequently sighted near Reddipalli village in the Sri Lankamaleswara Wildlife Sanctuary, Cuddapah district,

Table 4.1 Beaufort scale wind speed translations. (Sutherland, 1996)

Beaufort number	Name of wind	Velocity (km/hour)
0	Calm	<2
1	Light air	2 to 5
2	Light breeze	6 to 12
3	Gentle breeze	13 to 20

Andhra Pradesh. Efforts to listen and record their calls were made in other parts of the Sanctuary as well mainly in the places where the Jerdon's Coursers presence was confirmed by their footprints. Once the site was deemed active, it was re-visited in a regular interval on all seasons of the year.

4.3 Methods

4.3.1. Listening for the nocturnal bird calls

Calls were monitored from about sunset to about 80 minutes after sunset, and from about 80 minutes before sunrise up to sunrise. All the calls of the nocturnal birds were noted along with the following information for each session: date, time of first spontaneous call heard within about 300 m radius from the point where the calls were listened, cloud cover, wind speed (Beaufort Scale, see Table 4.1), presence/absence or visibility of moon. Cloud cover was visually estimated and classed as 0-25%, 26-50%, 51-75% and >75%. Call listening was not usually conducted in inclement weather.

To discriminate the Jerdon's Courser calls from those of the other birds in the Sanctuary, it was necessary to eliminate the calls of other species. Other crepuscular and nocturnal species that are now known to occur in the study area are Red-wattled Lapwing, Stone Curlew, Eurasian Eagle Owl *Bubo bubo*, Collared Scops Owl *Otus bakkamoena*, Spotted Owlet *Athene brama*, Indian Jungle Nightjar *Caprimulgus indicus*, Jerdon's Nightjar *Caprimulgus atripennis*, Common Indian Nightjar *Caprimulgus asiaticus* and Franklin's Nightjar *Caprimulgus affinis*. Since the beginning of the study, the calls of these species have been recorded and catalogued along with the calls of other species occurring in the Sanctuary, which could possibly be confused with that of the Jerdon's Courser.

4.3.2. Recording and analyzing the nocturnal bird calls

All calling activity was recorded using a Marantz PMD222 tape recorder with an Audio Technica AT815 unidirectional microphone, with no sound filters. Listening and recording were carried out mainly during clear still evenings and nights with no precipitation and low winds. Attempts were made to approach vocal birds as closely as possible to obtain high-quality recordings. Recordings of calls were analysed using the Syrinx, (version 2.2) which, is a PC-based software package designed for interactive playback of animal vocalizations and for digital sound recording and analysis in the lab or in the field (Mennill & Ratcliffe 2000).

4.4. Results

4.4.1 Recording and identification of the call

A call of the type that was later attributed to the Jerdon's Courser was heard on February 2001 and a Jerdon's Courser was sighted in the direction of the call a few seconds later. Identical calls were heard again on June and October 2001, but no birds were seen and no recordings were obtained during these occasions. The call was heard from places where the bird was seen to walk or fly within a few seconds. The first recording of the call was obtained during November 2001. Final confirmation that the call was made by a Jerdon's Courser was obtained on May 2002 when a Jerdon's Courser was observed while it was calling, before dusk and in ample sunlight. The distance between the observer and the bird was not more than 50 m in all of these instances.

4.4.2. Description of the Jerdon's Courser call

The short disyllabic call consists of a high-pitched first syllable, and rapidly descending second syllable, which can be rendered as either "*kwik-koo ... kwik-koo ... kwik-koo ... kwik koo...*" or "*yak-wak ... yak-wak ... yak-wak ... yak-wak...*". Each pair of syllables can be referred as a call. Birds have been heard to give between 2 and 16 calls in a sequence at a rate of about one call per second. On one occasion, the first syllable of the single call was heard several times and then the bird spontaneously called, "*kwik...kwik...kwik...kwik...kwik...kwik...kwik koo...*". Calls were often heard from more than one place. At the most, they were heard from three different places up to about 200 m apart within a period of a few minutes. The possibility of

the same bird moving and calling in such a case was unlikely, because of the pattern of calling in some instances.

4.4.3. Analysis of the recorded calls

Totally six recordings of the Jerdon's Courser calls were obtained from November 2001-January 2003, of which five were selected for further analysis based on the quality. The calls were recorded <50m from the calling bird, generally in windless conditions. These calls were loaded into the Personal Computer and the spectrograms with minimum background noise and high sound intensity were then examined using Syrinx program.

Spectrogram analysis of a single Jerdon's Courser call, shows that it consist of two repeated syllables, each separated by a short interval and the majority of the energy within the call occurs between 1 and 4 kHz, with the syllables showing three distinct bands throughout the frequency range. In effect, there are three notes at three different frequencies (1 kHz, 2 kHz and 3.5 kHz), which make up each syllable Figure.1a (single JC call sonogram and waveform). Wave form of the same call shows that most of the energy within the call falls between 0.25 to -0.25 mV. (Figure.1b). All measurements were made

Figure. 1a. Spectrogram (Time v Frequency) of a compe Jerdon's Courser call showing two syllabells seperated by an interval.

Figure. 1b. Same call represented in a waveform (Time v Amplitude)

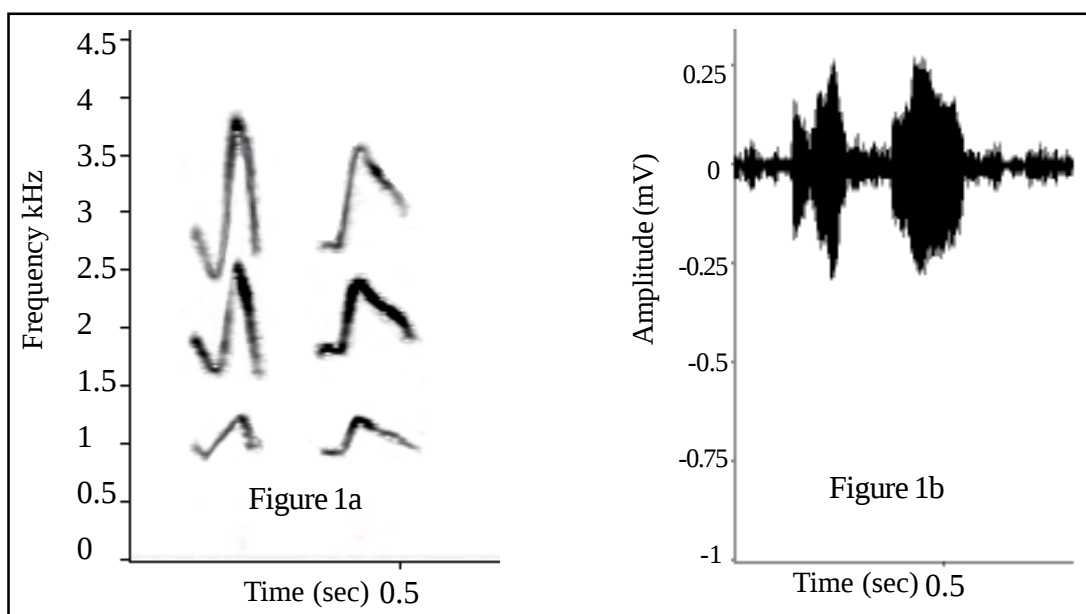
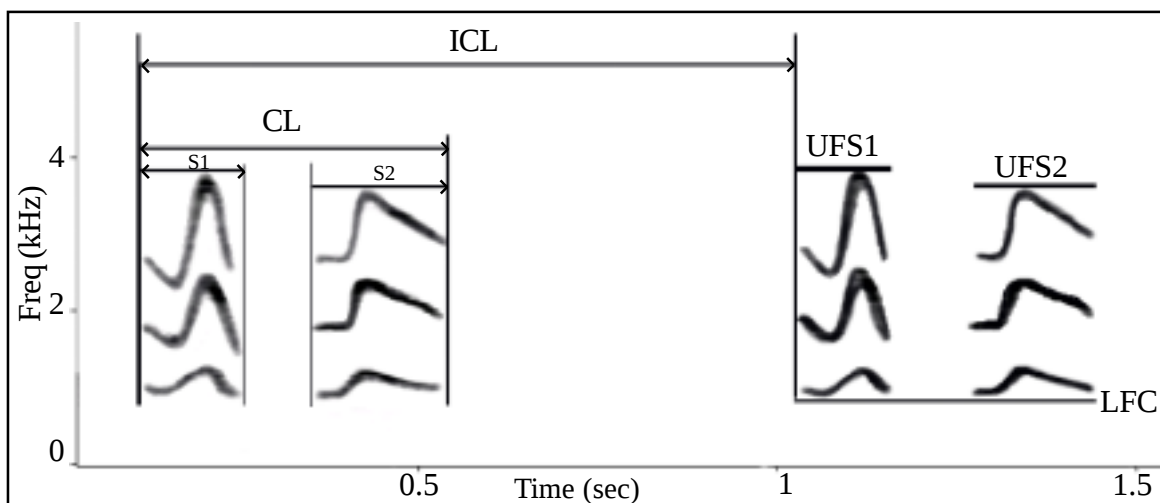


Table 4.2 Particulars of recordings of the Jerdon's Courser calls used for the analysis in this study

Date	Place	Total Calling time (sec)	Bouts	Bout duration (sec)	Time interval between bouts (sec)	No. of calls in each bout
12-11-01	JC1	45	3	8.3, 4.3 & 9	15, 8	7, 4, 6
13-11-01	JC1	22	2	11.2 & 7.8	2.7	10, 6
14-11-01	JC1	16	2	1.5 & 1.5	12.8	2, 2
06-06-02	B9JC	10	2	3.1 & 3.5	3.2	3, 3
13-01-03	T2B	18	2	9.2 & 7.3	1.4	9, 8

using on-screen cursors. Measurements of syllable characters were made from spectrographs displayed at the level of Figure 4. 2, resulting in a cursor increment of 0.05 ms.

Detailed measurements were taken from five recordings. Information on the place of recording, date and call details were given in Table 4.2. Each pair of syllables referred as one call. Series of calls with out pause referred as one bout. Number of calls within the bouts varies between 2 to 10. The time interval between bouts in a series of call differs from 1.4 to 15.0 seconds. While screening the recording, part of the calling that were of high quality were each bout of the Jerdon's Courser calls were segregated and made it as an individual sound files for further analysis. If the recording coincides with the other birdcalls or other background noises, they were eliminated by filtering it out by the standard setting option available in the software. This was done

Figure 4.2 Spectrographic representation of the two Jerdon's Courser calls showing the seven parameters measured within

only if the noise present in between the Jerdon's Courser calls. If both the Jerdon's Courser call and the other birdcall appeared at the same time, the frequency level of that particular call or the part of the call was not measured. Figure 4. 2 shows how detailed measurements were taken from the sonogram for the duration of syllable 1 & syllable 2 (S1 & S2), total call length with the interval between (CL), upper frequency limits of syllable 1 & syllable 2 (UFS1 & UFS2), lower frequency limit of the call (LFC), Inter call length (ICL).

Measurements taken from the spectrographs of the Jerdon's Courser call shows that the mean length of the complete Jerdon's Courser call with the short interval in between (CL) was $0.482 \text{ sec} \pm 0.055$ ($n = 11$) (Table 4.3). The call comprises the short first syllable (S1) (mean = $0.158 \text{ sec} \pm 0.011$, $n = 11$) and the relatively longer second syllable (S2) (mean = $0.231 \text{ sec} \pm 0.030$, $n = 11$).

The highest trace present on the spectrograph of the Jerdon's Courser call or the upper limit of the first syllable was generally higher in the frequency than that of the second syllable. The lowest trace present on the spectrograph or the lower frequency limit of the two syllables was almost the same. On average the Jerdon's Courser call falls between $0.686 \text{ kHz} \pm 0.071$ to $3.446 \text{ kHz} \pm 0.032$ (Table 4.4).

By using the time/frequency cursors, Inter Call Length (ICL) was measured. It starts from the beginning of one call to the beginning of the successive call including the silent period between calls (Figure.2). On few instances, within the series of calls there was a long pause between one bout and the

Table 4.3. Means and standard deviations of the measurement of the Jerdon's Courser call characters. n is the number of bouts. S1 & S2, the duration of Syllable 1 & Syllable 2 (sec), CL, total Call Length with the interval between (sec).

Recording details	S1 (Sec)		S2 (Sec)		CL (Sec)		Bouts (n)
	Mean	sd	Mean	sd	Mean	sd	
12-11-01 JC1	0.166	0.009	0.274	0.009	0.548	0.014	3
13-11-01 JC1	0.169	0.002	0.260	0.007	0.542	0.005	2
14-11-01 JC1	0.161	0.009	0.200	0.003	0.473	0.017	2
6-6-02 B9JC	0.140	0.011	0.210	0.005	0.432	0.014	2
13-1-03 T2B	0.151	0.007	0.208	0.009	0.416	0.013	2
Average	0.158	0.011	0.231	0.030	0.482	0.055	

Table 4.4. Means and standard deviations of the three frequency characters measured from the call the Jerdon's Courser. UFS1 & UFS2, Upper Frequency imits of Syllable 1 & Syllable 2 (kHz). LFC, Lower Frequency limit of the Call (kHz). *n* is number of bouts measured.

Recording details	UFS1 (KHz)		UFS2 (KHz)		BOUITS (<i>n</i>)	LFC (kHz)		BOUITS (<i>n</i>)
	mean	sd	mean	sd		mean	sd	
12-11-01 JC1	3.404	0.066	3.065	0.095	3	0.612	0.006	3
13-11-01 JC1	3.421	0.001	3.025	0.090	2	0.627	0.000	2
14-11-01 JC1	3.482	0.330	3.228	0.373	2	0.731	-	1
6-6-02 B9JC	3.456	0.039	3.268	0.069	2	0.780	0.079	2
13-1-03 T2B	3.465	0.089	3.064	0.037	2	0.678	0.019	2
Average	3.446	0.032	3.130	0.110		0.686	0.071	

following one. So the bouts with continuous calls were separated and stored as different files for this analysis (Table 4.5). If there were only two calls present in one bout, it was considered as one pair of calls. The Inter Call Length (ICL) measured from the forty pairs of the Jerdon's Courser call shows that average length was $1.241 \text{ sec} \pm 0.210$.

Table 4.5. Mean and standard deviation of the Inter Call Length (ICL) of the Jerdon's Courser calls. *n* is number of pairs of calls measured.

RECORDING DETAILS	mean	sd	<i>n</i>
12-11-01 JC1A	1.404	1.404	1
12-11-01 JC1B	1.292	1.292	1
12-11-01 JC1C	1.506	0.168	5
13-11-01 JC1A	1.156	0.118	9
13-11-01 JC1B	1.464	0.103	5
14-11-01 JC1A	0.950	0.950	1
14-11-01 JC1C	1.021	1.021	1
06-06-02 B9JC A	1.283	0.004	2
06-06-02 B9JC B	1.496	0.060	2
13-01-03 T2B A	1.095	0.182	7
13-01-03 T2B B	0.986	0.062	6
Total	1.241	0.210	40

4.4.4. Monitoring the calling behavior

Calls were monitored on 12 sites (Figure.4.3, Map 4.1& 4.2). These sites were selected because either the presence of the Jerdon's Courser was confirmed by its footprints, or calls were heard at least once from these sites during the preliminary survey. Jerdon's Courser presence was confirmed in three sites (B3, JC2 & B6) only by their footprints. In four sites (JC1, JC3, B9 & T2B) Jerdon's Coursers calls were heard as well as the footprints were also obtained. In the rest of the sites, only calls were heard (Table 4.6). Number of call monitoring sessions for each year (from 2001-2004) is not uniform and it varies seasonally. Maximum number of listening sessions across all the seasons was during 2002 and the minimum was during 2004. Number of call monitoring sessions was high during summer (46) followed by winter (33) and northeast monsoon (30) seasons. The lowest number of monitoring sessions was during southwest monsoon season (16).

Call listening was carried out mainly during the dusk starting just before sunset. Cloud cover, Wind speed (in Beaufort scale) was also noted during the call listening session. Mean duration of the listening period was 41.9 minutes ($n = 125$ listening sessions). It ranges from 16 minutes to 101 minutes depending upon the weather conditions. Frequency of visits for each site varies from 1 to 39. Jerdon's Courser calling rate in relation to different environmental conditions and seasons were analysed using contingency table and G-test.

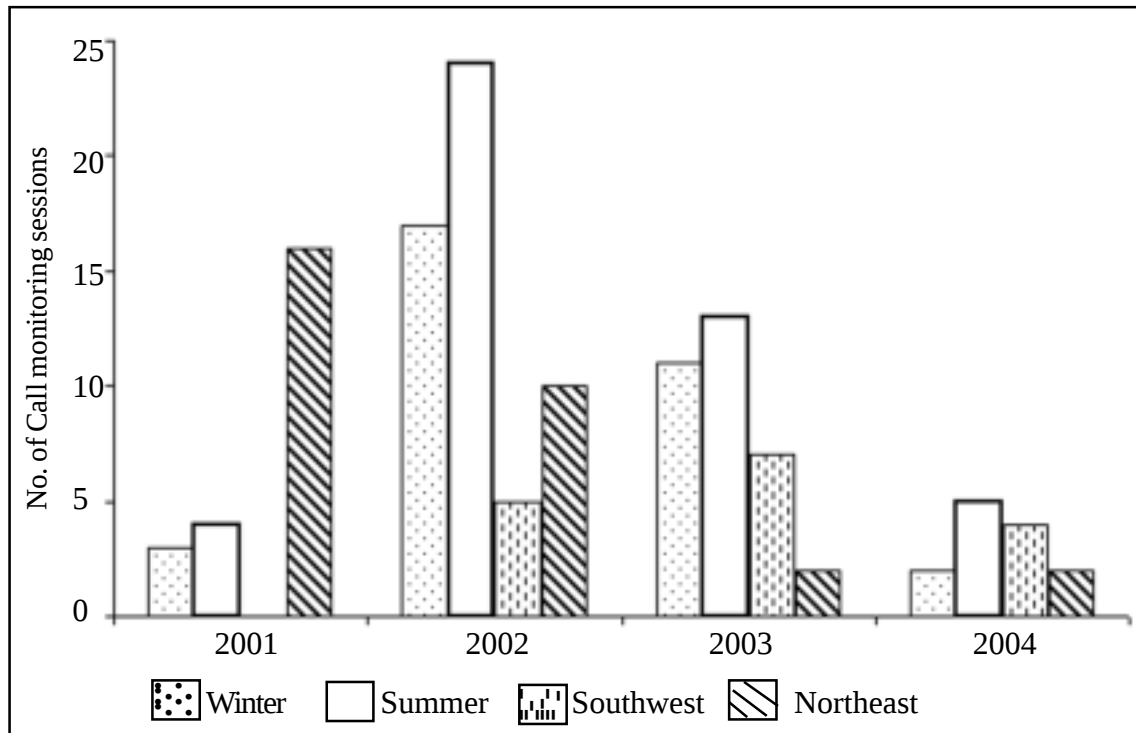
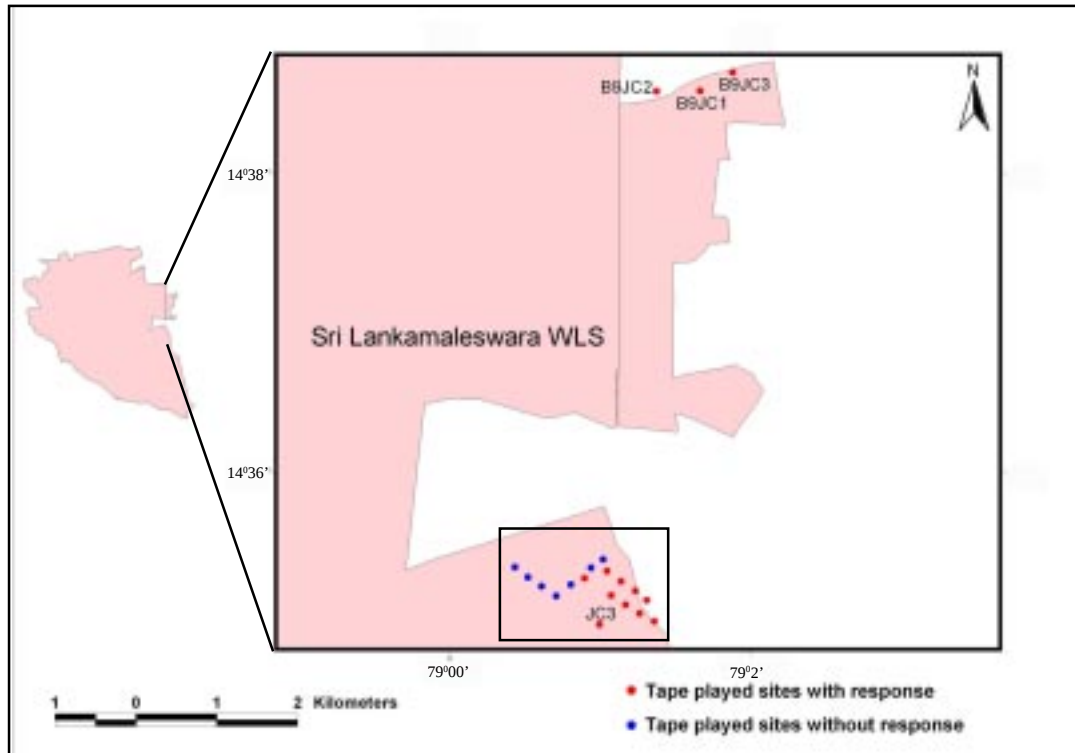
Figure 4.3 Year wise breakup (2001-2004) of the call monitoring sessions for four seasons.

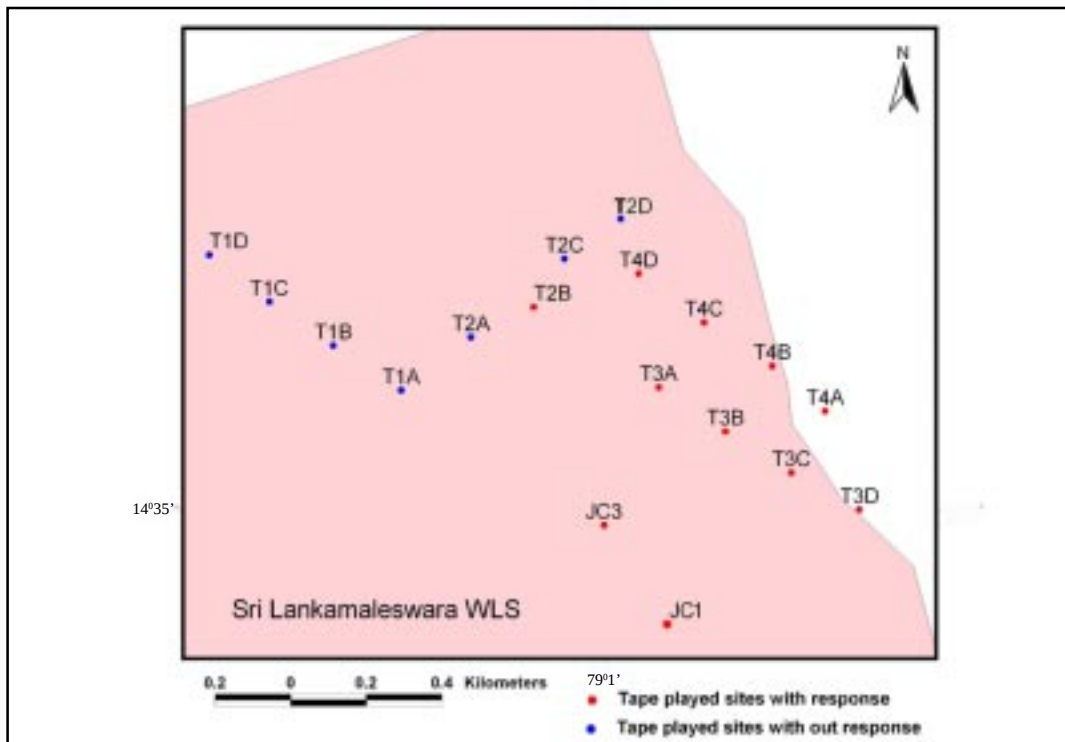
Table 4.6 Details of each sites monitored for Jerdon's Courser call. Number of visits, time spent (in minutes), the total number of spontaneous call heard in each sites and call rate are also given. Jerdon's Courser presence was detected at least once in each of these sites. * indicate sites where Jerdon's Courser presence was confirmed only by means of their footprints. # indicate sites where both calls heard as well as the footprints seen. Only calls were heard on rest of the sites.

Sl. No.	Site	Total number of visits	Total time spent (min)	No. Occasions Jerdon's Courser call heard	Call rate (call/visit)
1	B3*	11	330	0	0.000
2	B6*	3	91	0	0.000
3	B9#	14	529	0	0.000
4	JC1#	27	1145	7	0.259
5	JC2*	4	227	0	0.000
6	JC3#	39	1918	10	0.256
7	T2B#	16	593	5	0.313
8	T3A	3	119	1	0.333
9	T3D	2	52	0	0.000
10	T4A	3	122	0	0.000
11	T4B	1	50	0	0.000
12	T4D	2	60	1	0.500
	TOTAL	125	5236	24	0.192

Map 4.1 shows the sites where the tape playback experiment carried out in and around the Sri Lankamaleswara Wildlife Sanctuary. Box indicates the area where the Jerdon's Courser known to be present from 1986.



Map 4.2 shows the sites where the tape playback experiment carried out near the known Jerdon's Courser area in and around the Sri Lankamaleswara Wildlife Sanctuary.



4.4.5. Jerdon's Courser spontaneous calling rate

Out of 12 sites, three sites were monitored regularly through out the year; two sites were monitored on three seasons. Eighty six percent of the total time spent constituted from these five sites. Four sites were monitored on two seasons and three of them were monitored for only one season (14% of total time spent). Total time of call listening period for all the sites, on all seasons was 5236 minutes ($n = 125$). Overall calling rate for all seasons was 0.192 spontaneous call/visit. Call of the Jerdon's Courser was heard on five sites JC1, JC3, T2B, T3A & T4D. Frequency of calling was more in JC3 (on 10 occasions) and the less in T3A & T4D (on one occasion). There was no spontaneous call heard on rest of the sites (Table 4.6).

4.4.6. Seasonality of calling rates

Call listening sessions were classified into four seasons' namely winter, summer, southwest monsoon and northeast monsoon. Details of number of sites visited during four seasons can be seen in Table 4.7 Overall time spent for the entire seasons from all the sites was 5236 minutes. Of which 31.6 % was during the winter followed by 31.2 % in the summer. In the monsoon periods, 25.4% was in northeast and 11.8 % was in southwest. Rate of calling was relatively higher during north-east monsoon followed by winter. The frequency of calling was low during summer and south-west monsoon. Spontaneous call differs significantly across the four seasons ($\chi^2 = 20.86$, $P = 0.0001$, $df = 3$). Site wise analysis for spontaneous calling for all seasons' shows that percentage of calling was higher in JC3 (60%) followed by T2B (22.5%). It should be noted that not all the sites were monitored on all four seasons. Three places (JC1, JC3 & T2B) were monitored for all four seasons and two places (B3 & B9) were monitored except during northeast monsoon.

4.4.7. Influence of visibility of moon, cloud cover and wind velocity on the spontaneous calling of the Jerdon's Courser

During the call listening session, visibility of moon, cloud cover and wind velocity were noted. Cloud cover was visually estimated and classed as 0-25%, 26-50%, 51-75% and >75%. Wind velocity was noted on the scale: 0= <2 km/hour (Calm), 1= 2-5km/hour (Light air), 2= 6-12km/hour (Light breeze), 3= 13-20km/hour (Gentle breeze). Wind velocity was estimated by using the Beaufort scale (Sutherland, 1996).

Table 4.7 Details of total number of sites visited and Jerdon's Courser calls heard during four seasons. Spontaneous call rate/visit of the Jerdon's Courser was also given.

Seasons	No. of occasions calls heard	No. of visits	Call rate (call/visit)
Winter	8	33	0.242
Summer	1	46	0.022
South-West	2	16	0.125
North-East	13	30	0.433

Table 4.8. Calling behavior of the Jerdon's Courser in relation to visibility of moon, cloud cover and wind velocity across 125 observation evenings.

Parameters	Categories	Jerdon's Courser Call	
		Heard	Not heard
Moon	Visible	10	31
	Not visible	14	70
Cloud Cover	0-25%	16	66
	26-50%	3	15
	51-75%	1	7
	>75%	4	13
Wind velocity (Beaufort Scale)	Calm (<2 km/h)	17	45
	Light air (2-5 km/h)	4	34
	Light breeze (6-12 km/h)	3	20
	Gentle breeze (13-20 km/h)	0	2

The Jerdon's Courser was heard calling on 24 occasions out of the 125 call listening sessions. Details of the calling behavior of the Jerdon's Courser in relation to visibility of moon, cloud cover and wind velocity across these 125 call listening sessions are given in Table 4.8. On 14 occasions, Jerdon's Courser's calls were heard when moon was not visible and it was heard on 10 occasions when moon was visible. There was no significant variation in calling with moon visibility ($\chi^2 = 1.06$, $P = 0.303$, $df = 1$).

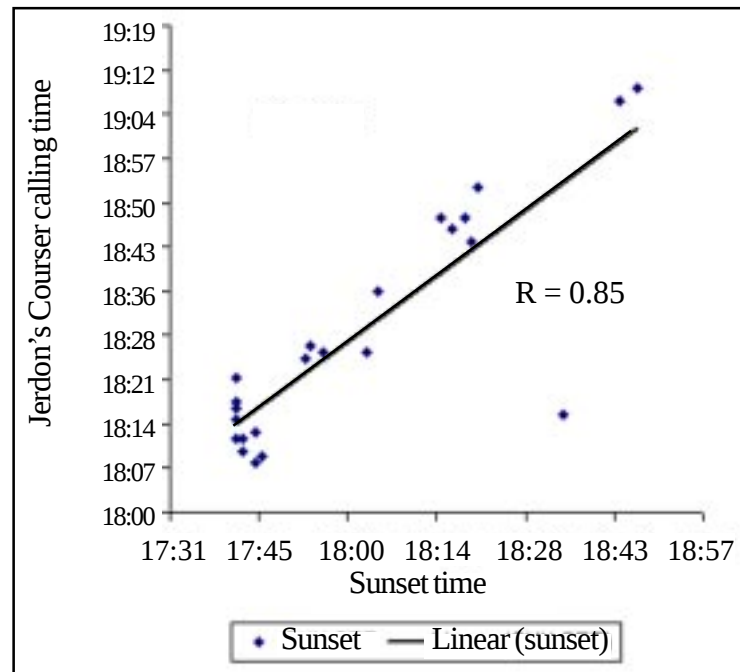
Greater number of Jerdon's Courser spontaneous calls were heard (16) when the sky was generally clear (cloud cover 0-25%), and it was heard on only one occasion when the sky was with 51-75% cloud cover. Likewise similar kind of pattern was observed when the Jerdon's Courser calls were not heard (on 66 occasions when cloud cover is 0-25% and 7 when cloud cover is 51-75%). However there was no significant pattern in spontaneous calling for the different cloud cover classes ($\chi^2 = 0.515$, $P = 0.910$, $df = 3$).

Jerdon's Courser calls were heard mainly under windless condition (on 17 occasions) and it was not heard when the wind velocity is 13-20 km/h. G-test (log likelihood test) was performed to find out the level of significance of variation in calling behavior under 4 categories of wind velocity. This resulted in $G = 6.56$ $P = 0.1$ ($df = 3$).

4.4.8. Timing of calling

During the call listening sessions, time of the first call of the Jerdon's Courser after the sunset was also recorded. Timings were noted up to the minutes level. Sunset data for the study area was obtained from <http://aa.usno.navy.mil/>, which was accessed on August 23, 2005. The relationship between the time of call and the sunset was assessed by Pearson's correlation of coefficient. It suggested that there is a positive correlation between the timing of sunset and the first call of the Jerdon's Courser was heard ($R^2 = 0.731$) On an average, spontaneous calls were started 29 ± 0.04 minutes after sunset ($n = 23$) (Figure 4.4). It ranges from 20-40 minutes after sunset depending upon the season. Jerdon's Courser has been heard to give between 2 to 16 calls in a sequence, at a rate of about one call per second. The calling period is quite brief, starting 20-40 minutes after sunset and continuing for a few minutes to about 20 minutes. It has been estimated that the call can be heard from a distance of 200 to 250 m.

Figure 4.4 Relationship between the time of sunset and the time of the first call of the Jerdon's Courser heard.



4.4.9. Eliciting calls from Jerdon's Courser by playing tapes of their calls.

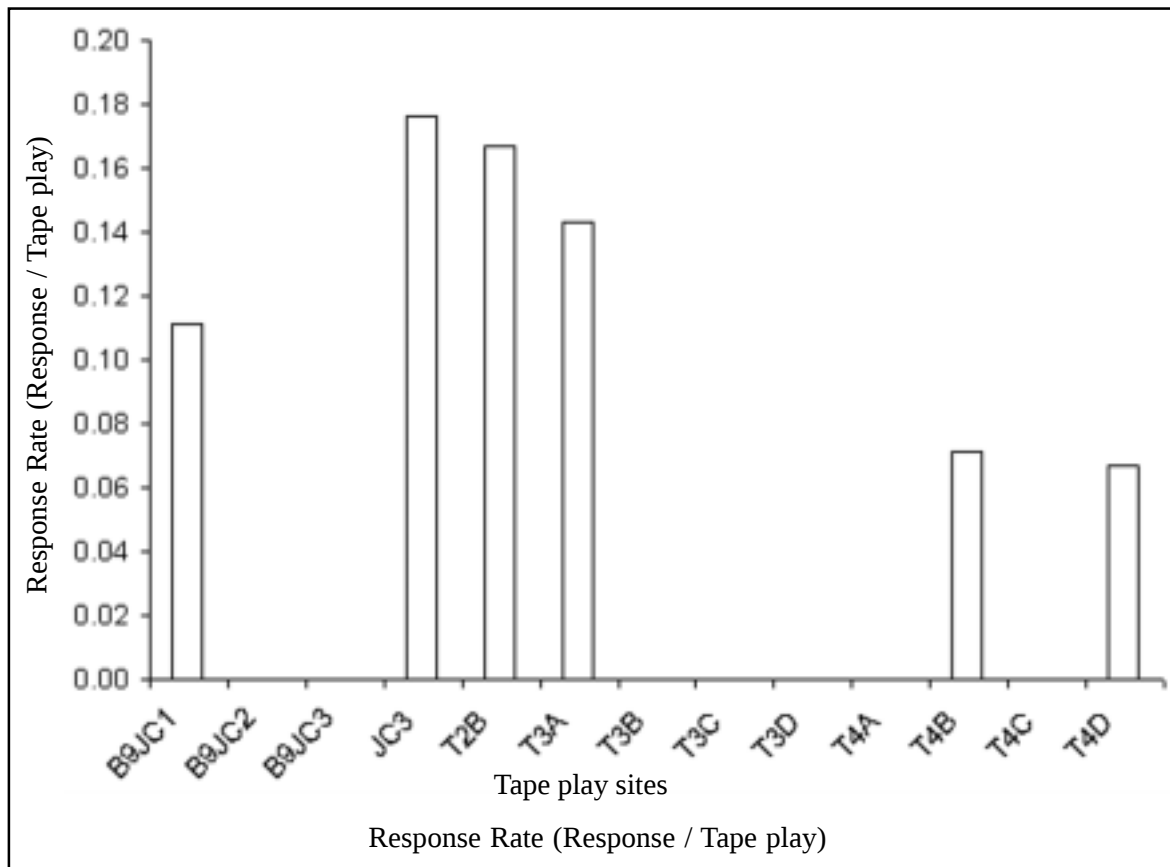
Tape play back involve, playing a standard one minute duration tape loop cassette with 4 bouts of calling, each of 10 calls at c.1 second intervals, each bout separated by 5 seconds of silence, from a fixed point in scrub jungle mainly in the evening (45-90 minutes after sunset). This tape was played for one minute, on a double-speaker portable cassette player and faced the speaker towards each of four directions at 90-degree separation for each bout of ten calls. The bearing, range, time of response and duration of calling by Jerdon's Courser were recorded.

Trials of playing a tape recording of Jerdon's Courser calls on 17 sites in suitable habitat within about 1-2 km of the previously known site during the evening elicited responses from Jerdon's Courser from nine sites. Also tapes were played in a systematic manner (see Chapter 5) in the potentially suitable habitat where the Jerdon's Courser was not known previously. This resulted in eliciting the response from the Jerdon's Courser on three sites. This area is about 7 km from the previously known site (Map 4.1 & 4.2).

Table 4.9 Details of number of tape playback surveys conducted in 13 sites from March 2002 to March 2003 (except during August, September & October). Sites from where response elicited from the Jerdon's Courser was also given.

Sites	Number of tape play	Response
B9JC1	9	1
B9JC2	7	0
B9JC3	9	0
JC3	17	3
T2B	12	2
T3A	14	2
T3B	14	0
T3C	14	0
T3D	14	0
T4A	14	0
T4B	14	1
T4C	14	0
T4D	15	1
Grand total	167	10

Figure 4.5 Jerdon's Courser response rate for its own call in 13 different sites from March 2002 to March 2003.



Based on the results of the trials twelve sites were selected for systematic tape playback survey. One more site (T4D) was also selected for regular tape playback since the spontaneous call was heard and also footprints were recorded from the soil strip placed c. 10 m away from this point. So totally 13 sites were surveyed from March 2002 to March 2003.

Five sites (B9JC1, B9JC2, B9JC3, JC3, T2B) were surveyed individually since they are situated far apart. Whereas in T3A to T3D and T4A to T4D the observer start from one site and walk to the next site as quickly as possible and play the tape for 1 minute. After reaching the subsequent site, calls were listened in that particular site for c.1 minute before playing the tape to determine whether the bird was calling prior to the tape play. All these eight sites were surveyed in one evening since the sites were c.200 m apart. It took 7-10 minutes to play the tape, listen for c.3 minutes (before and after the tape play) and then walk to the next site 200 m away. Tape play was started c.20-45 minutes after sunset. Tape playback survey was conducted once or twice in a month. An interval of 10 to 25 days was maintained between the surveys in each site. Surveys were not carried out during August, September and October due to the inclement weather. During the 10 months survey from March 2002 – March 2003 (except during August, September & October), on 13 sites totally 167 tape playbacks were carried out (Table 4.9). Rate of response to the playback in relation to different environmental conditions and seasons were analysed using contingency table.

4.4.10. Response Rate

This resulted in eliciting response from Jerdon's Courser on 10 occasions from 6 sites. Overall response rate for all sites and all seasons was 0.060 responses/tape play. Site wise analysis of response rate reveals that it was relatively higher in JC3 (0.176 response/tape play) than the rest of the sites. (Figure 4.5). Tape playback survey efforts were classified into four seasons' namely winter, summer, southwest and northeast monsoon. Response rates were relatively higher during summer and northeast (0.077 and 0.089 response/tape play respectively) (Table 4.10). However the response rate was not varying significantly across the season ($\chi^2 = 2.17$, $P = 0.53$, $df = 3$).

Table 4.10. Details of total number of tape played from March 2002 to March 2002 (except during August, September, & October) and responses elicited from the Jerdon's Courser across four seasons.

Seasons	Total No. of Tape play	Response	Response Rate (Response / Tape play)
Winter	39	1	0.026
Summer	52	4	0.077
South-West	31	1	0.032
North-East	45	4	0.089

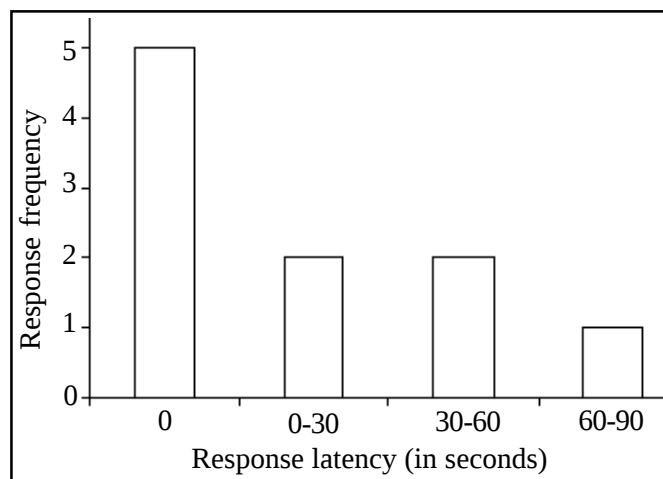
4.4.11. Influence of cloud cover, wind velocity and visibility of moon on the response of the Jerdon's Courser

Environmental parameters such as percent cloud cover, wind velocity and visibility of moon were noted during the each tape playback session. However none of these variables were affecting the response of the Jerdon's Courser significantly (cloud cover - $\chi^2 = 1.15$, $P = 0.97$, $df = 3$, wind velocity - $\chi^2 = 2.77$, $P = 0.65$, $df = 3$, visibility of moon - $\chi^2 = 0.11$, $P = 0.75$, $df = 1$).

4.4.12. Response latency

Response latency (difference between the time when tape stopped and the time of bird response heard) was measured during all the responses given by the Jerdon's Courser for its own call. Fifty percent of the responses were elicited immediately after the tape was switched off (within 0-10 seconds) but after 1 minute on one occasion. However, all of the responses began within 2 minutes of switching off the tape (Figure 4.6).

Figure 4. 6 Frequency distribution of response elicited and the response latency.



4.4.13. Non responsiveness for the tape

It was observed that Jerdon's Courser has been calling on its own before tape play on four sites on ten occasions. However, when the tape was played as soon as it had stopped calling (within 2-3 minutes), no response was elicited on 8 occasions (Table 4.11).

Table 4.11 Sites where the tapes played after the spontaneous calls of the Jerdon's Courser heard and the details of response elicited.

Site	No. of occasions call heard before tape play	No response after tape play	Response after tape play
T2B	3	2	1
JC3	3	2	1
T3A	3	3	-
T4D	1	1	-

4.4.14. Variations in call parameters among calls

While measuring the calls of the Jerdon's Courser, it was noticed that frequency and temporal parameters among the calls varied considerably especially among the sites. The similarities and dissimilarities of the calls recorded in three different locations were assessed by visual classification of sonograms followed by the quantitative analysis by using detailed measurements of frequency and temporal parameters of the calls. Call recordings made in T2B and B9JC appear to be from one individual. In the case of JC1 area, recordings were made on three evenings. It may be possible that calls recorded in JC1 area were from the same bird but this was not ascertained since the birds were not marked. Also birds were not seen while recording their call. For this reason the assessment was carried out to classify the calls mainly based on different locations rather than considering the recordings are from different individuals.

4.4.15. Visual classification of sonograms

Sonograms produced from the five recordings, which vary spatially and temporally were selected for visual classification. Details of the recordings were given in Table 4.12. These recordings were analyzed in spectrogram as well as in waveform. Three sonograms of the JC1 area calls shows that majority of the energy within the call occurs between 0.7 and 4 kHz and in the waveform it falls between 0.3 to -0.3 mV. The call length (CL) is c. 0.5 sec. (Figure 4.7 a & b). For the T2B calls majority of the energy within the call occurs between 0.6 and 3.4 kHz and in

Table 4.12. Details of Jerdon's Courser call recordings made for producing the sonogram used for visual classification. See also Map. 1 &2. for spatial distribution of the places of recordings obtained.

Place of recording	Date of the recording	Remarks
JC1	12,13 &14 -11-01	Main Jerdon's Courser Area
B9JC	06-06-02	c.7m away from JC1
T2B	13-01-03	c.800m away from JC1

the waveform it falls between 0.1 to -0.1 mV and the call length is c.0.4 sec (Figure 4.8 a & b). In the case of B9JC call it occurs between 0.7 and 3.4 kHz in the sonogram and in the waveform it fluctuate between 0.7 to -0.6 mV and the call length is c. 0.4 sec (Figure 4.9 a & b). It should be noted that recordings made from JC1 and T2B are the spontaneous call of the Jerdon's Courser whereas from B9JC it was the response for the tape play. So the fluctuation in the amplitude could be because of the strong vocal output for the tape play.

Figure 4.7a. Sonogram (Time v Frequency) of five Jerdon's Courser calls recorded in JC1 area on 13-11-01.

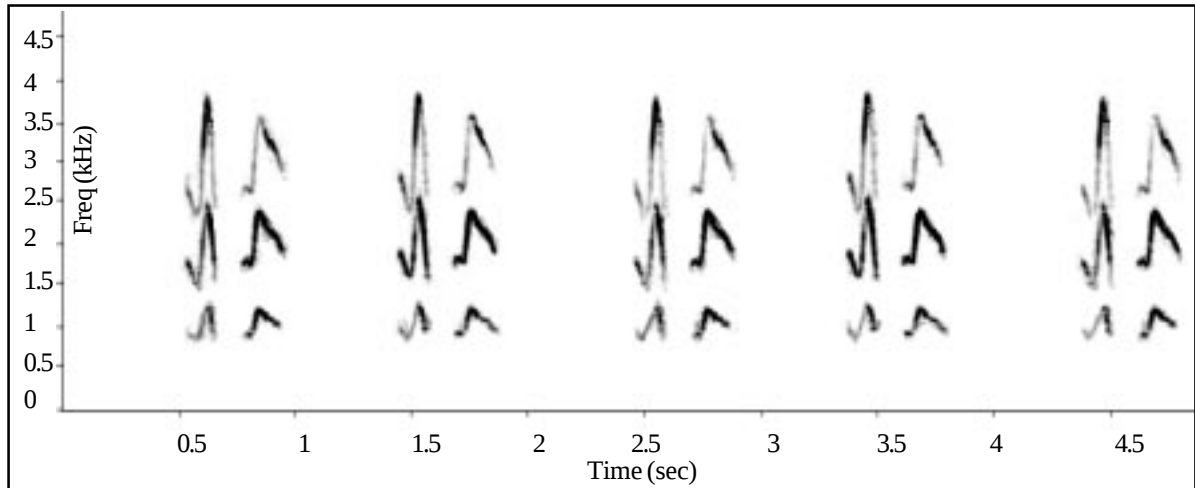


Figure 4.7b. Waveform (Time v Amplitude) of five Jerdon's Courser calls recorded in JC1 area on 13-11-01.

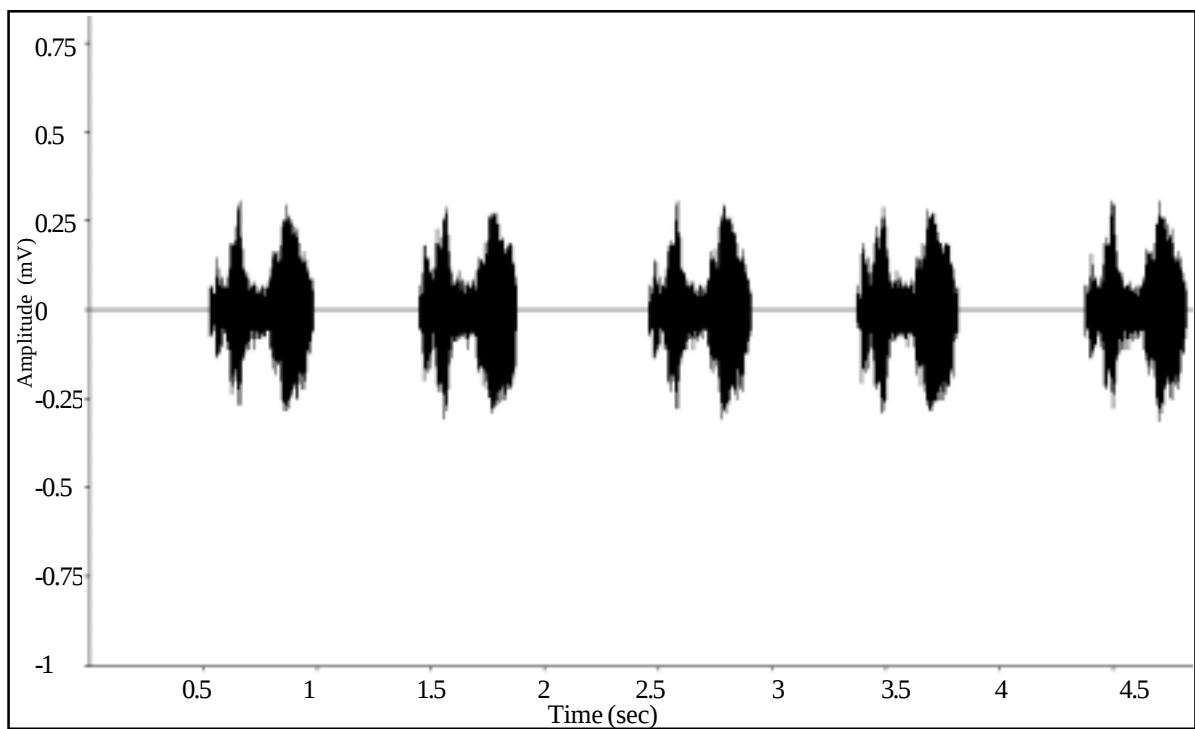


Figure 4.8a. Sonogram (Time v Frequency) of five Jerdon's Courser calls recorded in T2B area on 13-01-03.

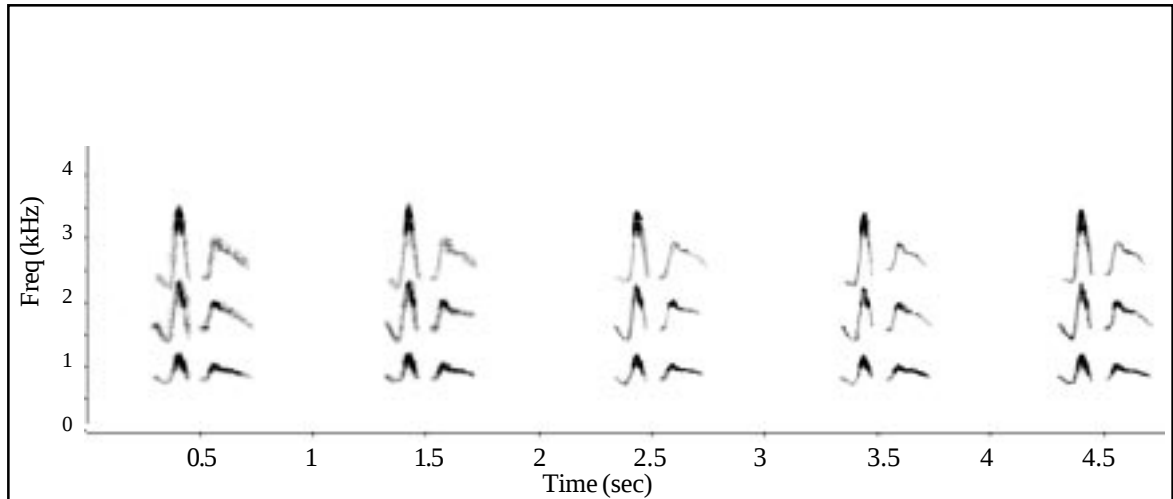


Figure 4.8b. Waveform (Time v Amplitude) of five Jerdon's Courser calls recorded in T2B area on 13-01-03.

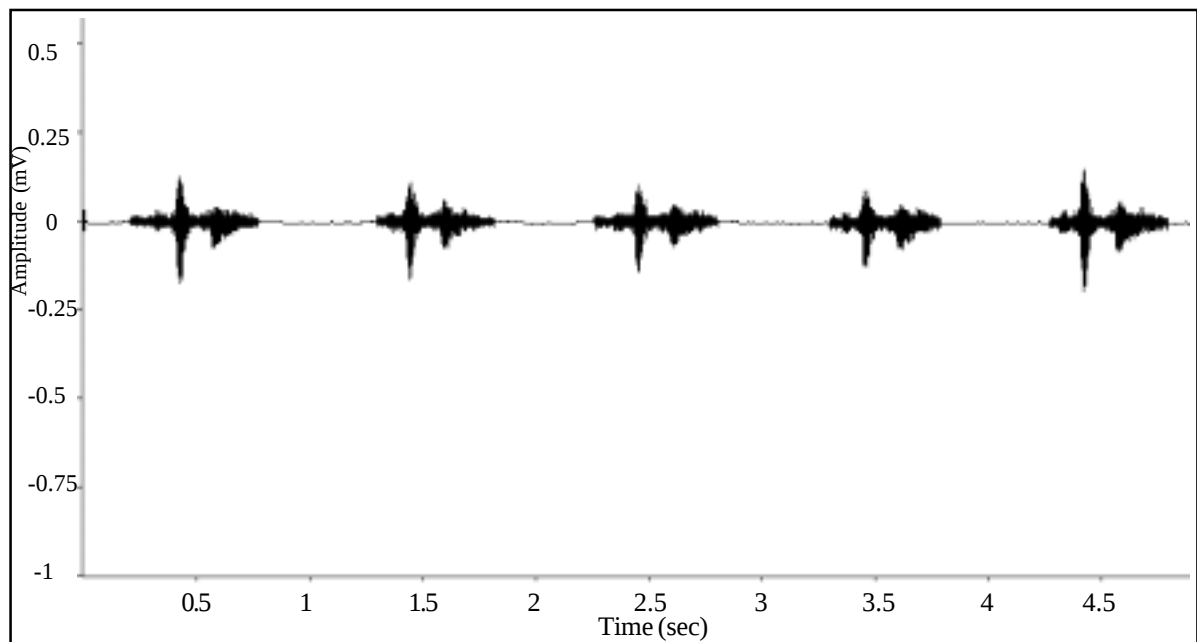


Figure 4.9a. Sonogram (Time v Frequency) of three Jerdon's Courser calls recorded in B9JC area on 06-06-02.

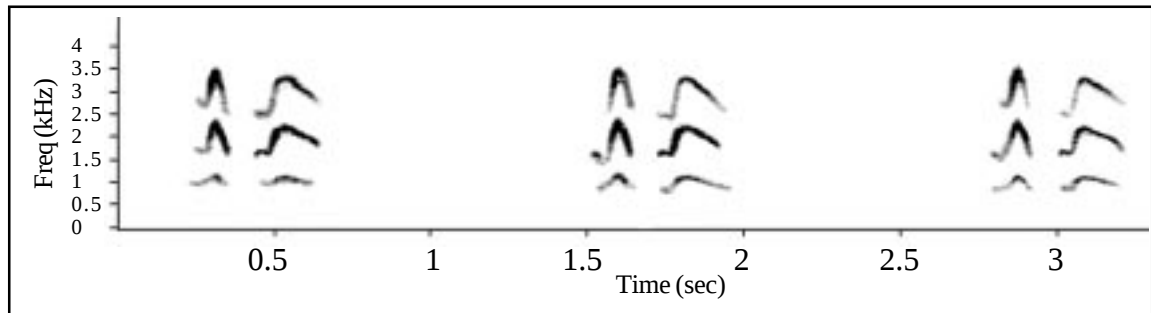
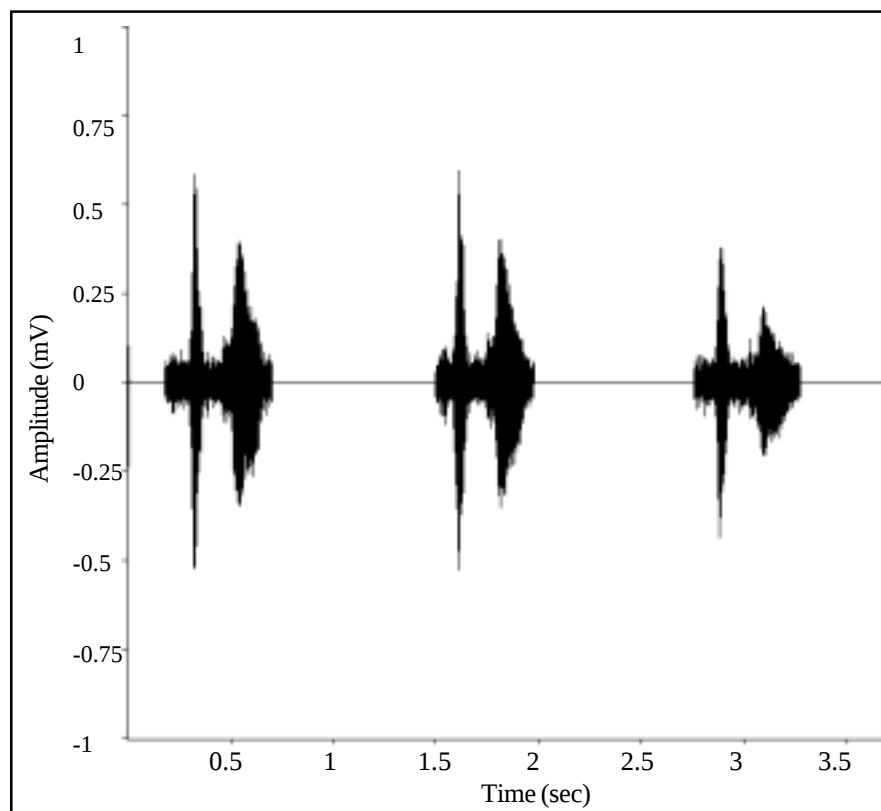


Figure 4.9b. Waveform (Time v Amplitude) of three Jerdon's Courser calls recorded in B9JC area on 06-06-02.



4.4.16. Quantitative analysis of the Jerdon's Courser call

Although the qualitative technique involving visual classification of the sonogram of different calls shows the variations within, it may not be robust. So the calls recorded from three different sites were analyzed using detailed measurements taken from the sonogram as shown in Figure 4.2. Stepwise discriminant function (DFA) analysis was used to differentiate the calls of the Jerdon's Courser. SPSS software (Version 10.0.1) was used for statistical analyses. Visual classification shows that, three sonograms from JC1 area were almost similar, so recordings from JC1 area were pooled for this analysis. For the visual classification, sonogram was produced for only a part of the series of calls, however for the statistical analysis, measurements taken from all the calls showed in Table 4.2 were used.

Six variables were taken from the Jerdon's Courser call as shown in Figure 4.2. The variables are: duration of syllable 1 & syllable 2 (S1 & S2), total call length with the interval between (CL), upper frequency limits of syllable 1 & syllable 2 (UFS1 & UFS2), lower frequency limit of the call (LFC). These variables were used in this analysis. An F statistic based on the one-way test of analysis of variance is used in the selection of the variables. Values of $F = 3.84$ and $F = 2.71$ were used to enter and remove variables in a forward manner. For cross-validation of the classification results, "Jack-Knife estimate" or "leave-one-out estimate" method was used.

The result shows that these recorded calls from three different places were discriminated with 96 % accuracy in original classification method and the leave-one-out (Jack-knife) estimator classified them with 92 % accuracy (Figure 4.10, Figure 4.11, Table 4.13). In this analysis 4 of 6 variables, which are listed in Table 4.14 selected to discriminate between the calls. Total call length with the interval between (CL), upper frequency limits of syllable 1 & syllable 2 (UFS1 & UFS2), and lower frequency limit of the call (LFC) characterized the first discriminant function (Table 4.14 & 4.15). In the cross-validated results, 3.4 % of JC1 area calls overlapped with T2B & B9JC calls. T2B calls and B9JC calls were overlapped interchangeably but none of these calls were misclassified in JC1 area calls. There was a 6.7 % overlap of T2B call with B9JC. Similarly 16.7 % B9JC calls were misclassified in T2B.

Figure 4.10. Group centroids and call clusters from three different recordings of three different locations on canonical function axis using 6 variables in DFA.

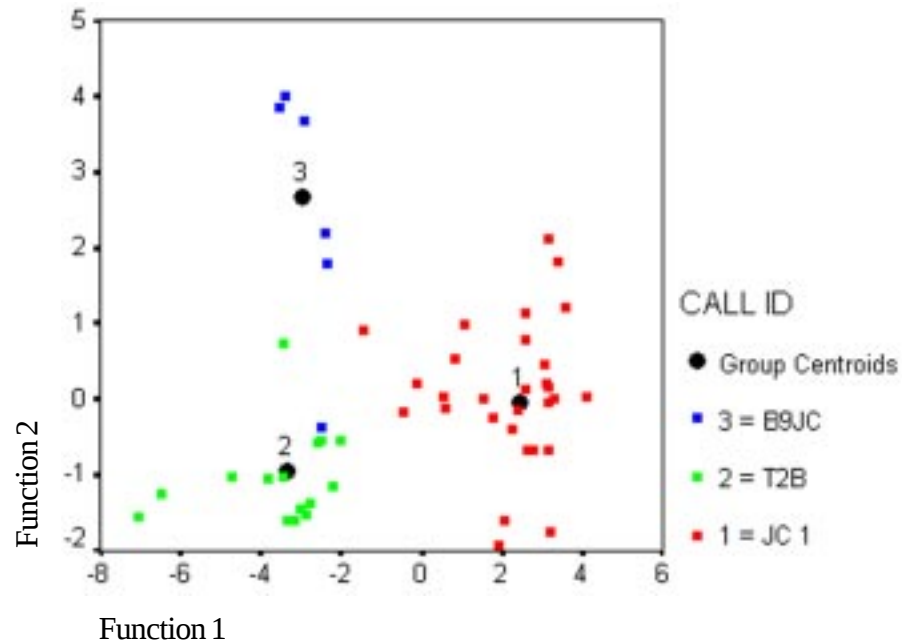


Table 4.13 Classification accuracy matrix for discrimination of three recordings from three different locations based on the call measurements (6 variables are used for DFA).

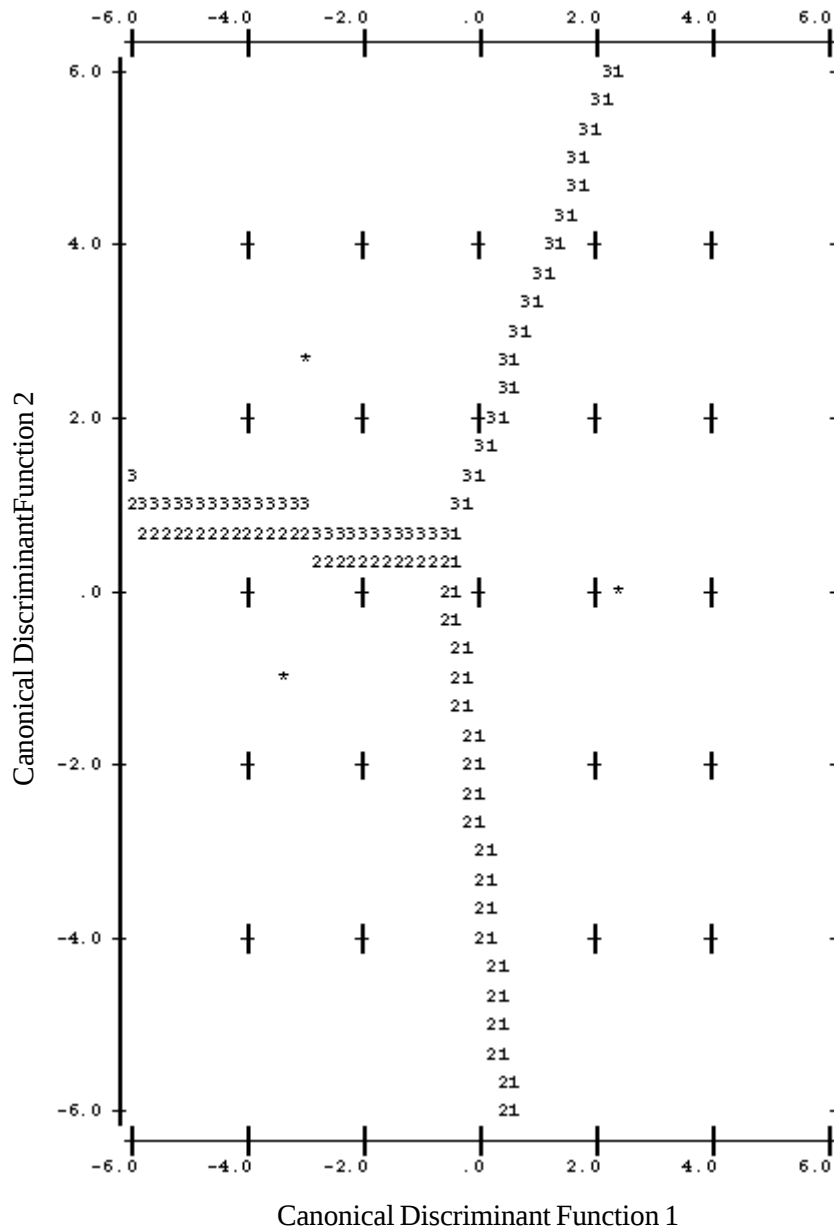
Classification Results ^{b,c}					
	Predicted Group Membership				Total
	CALLID	JC1	T2B	B9JC	
Original Count	JC1	28	0	1	29
	T2B	0	15	0	15
	B9JC	0	1	5	6
%	JC1	96.6	.0	3.4	100.0
	T2B	.0	100.0	.0	100.0
	B9JC	.0	16.7	83.3	100.0
Cross-validated Count ^a					
	JC1	27	1	1	29
	T2B	0	14	1	15
	B9JC	0	1	5	6
%	JC1	93.1	3.4	3.4	100.0
	T2B	.0	93.3	6.7	100.0
	B9JC	.0	16.7	83.3	100.0

a Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

b 96.0% of original grouped cases correctly classified.

c 92.0% of cross-validated grouped cases correctly classified.

Figure 4.11 Territorial map for discrimination of 3 calls recorded in three different locations based on the call measurement using 6 variables in DFA.



Symbols used in territorial map

Symbol	Group Label
1	JC1 area
2	T2B area
3	B9JC area
*	Indicates a group centroid

Table 4.14. Structure matrix for discrimination of calls recorded in three different locations based on 6 variables. Variables ordered by absolute size of correlation within function.

Structure Matrix		
	Function	
	1	2
CL	.796*	-.009
S2 ^a	.622*	.032
S1 ^a	.535*	-.007
UFS1	-.031*	.029
LFC	-.292	.742*
UFS2	-.063	.418*

Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions Variables ordered by absolute size of correlation within function.

* Largest absolute correlation between each variable and any discriminant function

^a This variable not used in the analysis.

Table 4.15 Discrimination function coefficients for discriminating 3 calls recorded in three different locations based on 6 variables.

Classification Function Coefficients			
	Call ID		
	JC1	T2B	B9 JC
CL	2520.868	2237.072	2313.093
UFS1	558.056	533.940	510.845
LFC	-35.870	-23.747	66.094
UFS2	195.412	173.587	187.471
(Constant)	-1930.075	-1651.580	-1713.671

Fisher's linear discriminant functions

4.5. Discussion

4.5.1. Vocalization and calling behavior

The recorded call of the Jerdon's Courser does not closely resemble any of the previous verbal descriptions. These may refer to calls not detected so far, or the previous identifications may have been mistaken. The calling period in the evening is quite brief, starting 20-40 minutes after sunset and continuing for a few minutes to about 30 minutes. It was not known whether the male or female bird producing the call. Frequency of calling varies seasonally and also it is site specific. Over all spontaneous call rate as well as the response rate was also very low. It should be noted that call surveys were carried out on the sites where the Jerdon's Coursers detected earlier. Low

rate of calling could be due to the possibility that the bird may not inhabit that area on all the season. Bart & Schoultz, (1984); Arcese *et al* (1988) and McShea & Rappole, (1997) suggest that calling rates may be related to density of individuals, so it may also be possible that the species itself occur in low density in certain sites during the study period.

Studies show that if food availability is less, birds tend to reduce song output and to have a lower call rates (Lucas *et al.*, 1999; Thomas, 1999 and van Oort, 2006). On the contrary increased food availability may result in higher vocal output (Strain & Mumme 1988, Berg *et al* 2005). So it is likely that in this study, differences in the resource availability might result in low call rates among sites. However i could not quantify the food availability among sites during my study.

Visibility of moon does not affecting either spontaneous calling or response rate of the Jerdon's Courser. Different phases of moon had been shown to affect calling rates of several nocturnal birds (Mills, 1986; Ganey, 1990 and Takats & Holroyd, 1997). It should be noted that calling rate in relation to the presence or absence of moon *per se* might not show the significant variation. Including more parameters such as calling in relation to different stages of lunar cycle (moon phase), percentage of moon face illuminated and moon height above horizon along with more sample size of calling instances would help in understanding the influence of moon light on the calling behavior of the Jerdon's Courser. Ambient level of moonlight may be an important factor for nocturnal foraging in Jerdon's Courser to detect their prey visually on the ground.

Although the Jerdon's Courser's spontaneous calls were heard more often during windless condition, significance level achieved during this study is very low ($G = 6.56$, $P = 0.1$) to determine the variation and is vulnerable to type 2 error. This could be because survey was not conducted during the inclement weather conditions, so there was not much observation when the wind velocity is 13-20 km/h. If the bird's propensity to call during such condition is actually affected then it can be ascertained only by using larger sample sizes under a wide array of wind velocity categories. However, rainy or windy weather conditions not only reduce the vocalization rates but tend to hampers the detectability of calls to listeners (Robbins, 1981; Chatwin, 1996; Peake & McGregor, 2001; Lengagne, & Slater, 2002 and Olsen *et al*, 2002).

None of the environment variables tend to affect the response rate of the Jerdon's Courser for the tape playback. Nevertheless, the rate of response was very low. More, sample size is needed to support this finding. Also the ambient temperature, which is one of the main parameters that can affect the calling behavior of birds (Garson & Hunter, 1979, Higgens, 1979 and Strain & Mumme, 1988), was not included during this study.

Two caveats need to be added here. Spontaneous call listening was more opportunistic rather than systematic except for few sites. Secondly, during the call listening and the tape playback survey it was assumed that Jerdon's Courser's inhabited the area when these surveys were carried out. However, while conducting this survey their presence can be established only by radio tagging them. This was not possible during this study since necessary permission was not available. Hence, this study is only a preliminary attempt to know the calling behavior of the Jerdon's Courser in relation to different environmental conditions. Therefore, these results need validation from more detailed observation and further research is needed, along with radio telemetry studies.

One of the main functions of call or song of many bird species is mate attraction (Catchpole & Slater 1995). Frequency of spontaneous calling of the Jerdon's Courser was relatively higher during northeast monsoon and winter, chiefly between November to February. After that the frequency decreased. Nothing is known about the breeding status of the Jerdon's Courser (Birdlife International, 2001). There is no authentic information available about breeding, but the male collected from Anantapur in June 1900 by Howard Campbell had enlarged testes so it could be breeding (Baker 1929). Although there was no nest found and/or young birds seen during this study period, the observation of the footprints of a young bird along with an adult Jerdon's Courser in one of the soil strips deployed in April 2002, suggests successful breeding in this study area. Also frequency of calling was relatively less from March onwards. So presumably, different stages of the breeding cycle of the Jerdon's Courser could fall somewhere in between November to May. Although, it would be premature to conclude anything from this limited information and observation, several studies indicate that calling rate increases generally during the breeding season

(Best & Petersen, 1982; Ganey, 1990 and Ishtiaq & Rahamani, 2004) and reduces and/or fluctuate during the later stages of the breeding cycle (Hanski & Laurila 1993; Tyler & Green 1996; Amrhein *et al*, 2002 and Amrhein *et al* 2004), which supports the assumption made on the breeding season of the Jerdon's Courser.

4.5.2. Potentialities of call listening and tape playback to detect the presence of the Jerdon's Courser in new areas.

Probability of hearing the spontaneous call of the Jerdon's Courser in one visit during the dusk, even in the places where it has been known to occur is 19% (call rate=0.192 call/visit) and the chances of eliciting the response/tape play from the Jerdon's Courser where it was known to occur is 6% (response rate = 0.060 response/tape play). Based on this estimate (R) if we want to find out the minimum number of visits and the tape play (K) to be made in the potentially suitable area where the Jerdon's Courser is not reported and to suggest that it is absent from that area with 1% chance of being wrong (V) in our conclusion then the target error rate can be attained if:

$$V = (1 - R)^K$$

$$K = \log(V) / \log(1-R).$$

$$K = \log(0.01) / \log(1-0.192) = 22$$

Similarly for the tape play

$$K = \log(0.01) / \log(1-0.060) = 75$$

Therefore, if we want to detect the presence of the Jerdon's Courser in the potentially suitable habitat then we will have to either visit that particular site for call listening for 22 evenings or play the tape in that site on 75 evenings. In case if there was no Jerdon's Courser record obtained after this effort then we can be 99% sure that it was not present during the survey period.

These calculations indicate that it would be impossible to survey a large area by following either by call listening or by tape playback. It is not only time consuming but also impractical. So the best way to survey the distribution of the Jerdon's Courser is soil strip method (see Chapter 3). Call listening can be followed in the places where there is a higher tracking rate of the Jerdon's Courser. It should be noted that the underlying assumption for both call listening and tape playback

was that the target species was present during the survey period. However, it was observed that on few instances Jerdon's Courser did not respond to the tape play even though its spontaneous calls were heard before the tape play (Table 11). The best estimates of spontaneous call and the response for doing large-scale survey can only be improved by radio-tagging the Jerdon's Courser.

4.5.3. Vocal individuality in the Jerdon's Courser– A preliminary assessment.

Discriminant Function Analysis (DFA) of the Jerdon's Courser calls from three different locations resulted in segregating them with 92% accuracy. The main objective of this analysis is to establish the variation within the Jerdon's Courser call. Even though the sample size is low this result clearly indicates that there is a variation within the Jerdon's Courser call.

Although the birds were not marked, calls recorded from T2B and B9JC are likely to be from two individuals. Because, while recording it was observed that the birds were given the series of calls at one stretch with very less time interval between 2 bouts (1.4 sec. & 3.2 sec. respectively), and there was no calls heard after that. Also these call recordings were differ spatially and temporally. So it may be established that these recordings are from two different individuals. DFA result shows that calls from these two sites were overlapped interchangeably. This could be due to low sample size. As far as the JC1 calls are concerned these recordings were made from one particular site for three consecutive evenings. Classification accuracy within the JC1 calls was 93.2% and only small proportion (3.4%) were misclassified in T2B and B9JC calls, however calls recorded from the last two sites were not overlapped with JC1 area call.

Assuming that the calls recorded from three different localities were of three different individuals based on the classification results, it may be possible to infer that, calls of the Jerdon's Courser can be used for vocal individualization. However it should be added here that, this study was only the preliminary attempt to explore the opportunity to individualize the Jerdon's Courser through its calls.

Several studies indicated the potential use of vocal individuality for monitoring the nocturnal and/or cryptic bird species (Delpont *et al.*, 2002; Galeotti *et al.*, 1993; Galeotti & Sacchi, 2001; Gilbert *et al.*, 2002; Jones & Smith, 1997; Peake & McGregor, 2001; Rebbeck *et al.*, 2001 and Terry & McGregor, 2002). Vocal individuality was also applied to estimate the level of site fidelity in African Wood Owls *Strix woodfordii* (Delpont *et al.* 2002) and to estimate the annual survival rate of Great Bitterns *Botaurus stellaris*, (Gilbert *et al.* 2002) and also to monitor level of movements of Corncrakes (*Crex crex*) and relate this to habitat quality (Peake & McGregor, 2001).

4.5.4. Recommendation for Radio-telemetry studies and use of Jerdon's Courser calls for long term monitoring.

Call counts and tape playback of bird calls were widely used to find out distribution, relative abundance and density of variety of bird species (Sutherland, 1996). Although calls were useful for measuring relative abundance and distribution of nocturnal birds it is difficult to assess their density without radio-telemetry studies. In the case of the Jerdon's Courser due to the low call and response rate it may not be feasible to use the call for detecting their presence in new areas. However, if the Jerdon's Coursers are studied through radio-telemetry it is possible not only to determine the size of an individual birds home range also to derive more precise estimates of number based on the call playback. It is possible to estimate the number of individuals present in an area by measuring the ratio of untagged to tagged individuals responding to tape playback. Since the number of tagged individuals is known, the total number of individuals present could be obtained using this ratio. Since the calls can be heard within the range of 250 meters it is possible to estimate the proportion of occasions precisely on which a radio-tagged Jerdon's courser responds to tape playback. This estimate of survey efficiency would be useful to convert the results of tape transects directly to density estimates. It was not known whether the male or female birdcalls recorded during this study. Through radio telemetry studies it may be possible to record the calls of birds, which are in different age group and sex.

Since the variation within the Jerdon's Courser calls were established during this study the next step should be recording more number of the calls from the radio-tagged individuals to recognize the stability of the vocal characters between years. To use the vocal individuality for census and monitoring it is imperative to establish the vocal characters describing a call remain constant within and between years (Gilbert *et al.* 1994, McGregor & Byle 1992). Once the call measurements were taken from the known individuals, any other new calls recorded from the unknown individuals can be analyzed and differentiate by using discriminant function analysis.

Considering the rarity as well as the nocturnal and elusive behavior of the Jerdon's Courser, applying the vocal individuality along intensive monitoring of marked individuals with radio-telemetry studies would be the best method and essential for long-term monitoring and censusing in the known Jerdon's Courser areas in the Sri Lankamaleswara Wildlife Sanctuary.

Chapter 5

Current status and distribution of the Jerdon's Courser

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5.1 Introduction

An accurate assessment of a species' distribution and up-to-date distribution maps are prerequisite for its effective conservation (Donald & Fuller 1998, Underhill & Gibbons 2002). According to Laughlin *et al.* (1982) and Harrison (1989), knowing the distribution of the species is important for answering several questions relating to bird conservation, protection and management. Distributional information can help in species prioritization for conservation, to find out the contraction of range by assessing repeated distributional maps and for selection of sites for bird conservation (Williams *et al.* 1996).

Distributional data of the two sub species of the Black Korhaan *Eupodotis afra* (Harrison *et al.* 1997) was helpful in splitting them into distinct species by using DNA studies (Crowe *et al.* 1994). It would also be useful to locate areas of high species richness (Balmford *et al.* 2001). Bibby *et al.* (2000) classified the distribution studies into three basic types: Atlas studies, Single species studies, and Habitat-based studies. They stated that distribution studies of single species require a fine-scale approach than the large-scale atlas studies. They have also suggested that a special case to study rare or low-density species by using look-see methods.

Geographical distribution of Jerdon's Courser is poorly known. There is no accurate map available on its spatial distribution even in the place where it has been seen regularly in and around the Sri Lankamaleswara Wildlife Sanctuary. Most of the sight records of the Jerdon's Courser are from the scrub jungle habitat, however there is no information on the extent and the distribution of the scrub jungle habitat. This study focused mainly to know the distribution of the Jerdon's Courser as well as the extent and distribution of the scrub jungle habitat in and around the Sri Lankamaleswara and Sri Penusila Narasimha Wildlife Sanctuary, Cuddapah District, Andhra Pradesh. Presence and the absence of the Jerdon's Courser was established by following the tracking strip and the tape transect methods explained in Chapter 3 & 4, while the distribution and the extent of the scrub jungle habitat was mapped with the use of remote sensing and GIS techniques.

5.1.2 Historical distribution of the Jerdon's Courser (1848-1900)

Jerdon's Courser was first recorded for science by T.C.Jerdon in c.1848. He found this species "from the hilly country above the Eastern Ghats off Nellore and in Cuddapah district" (Blyth 1848). In May 1867 W.T. Blanford sighted this bird "close to Sironcha on the Godavari" which is in the Eastern Maharashtra. Later in March 1871 he sighted it near Bhadrachalam, which is in Andhra Pradesh (Blanford 1898). In 1900 Howard Campbell recorded the Jerdon's Courser near Anantapur (Baker 1929) (Map 5.1). For almost 86 years, there was no sighting of the Jerdon's Courser, till it was rediscovered near Reddipalli, in Cuddapah district in January 1986 by Bhushan (1986a).

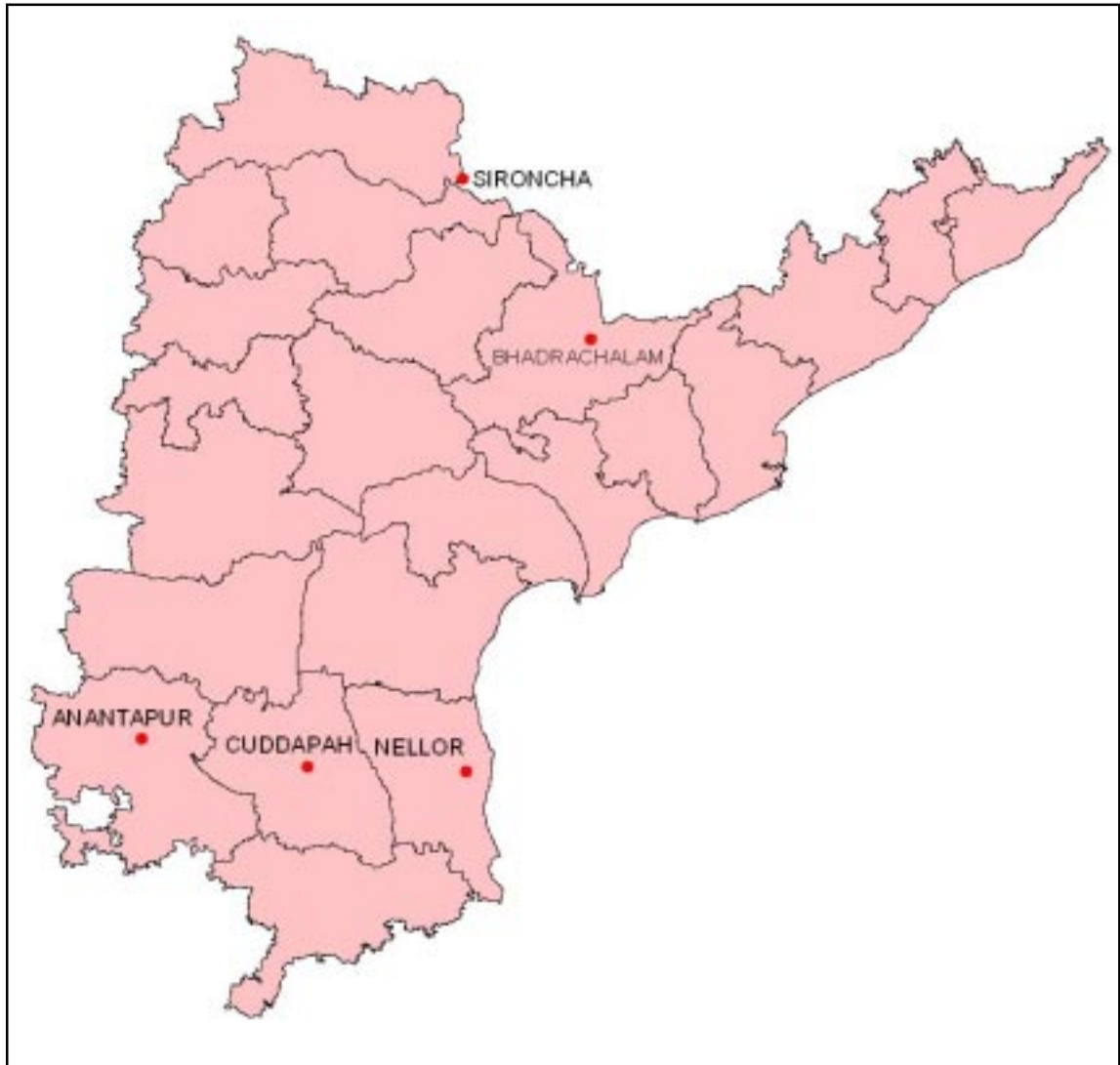
5.1.3 Recent records (1986-2000)

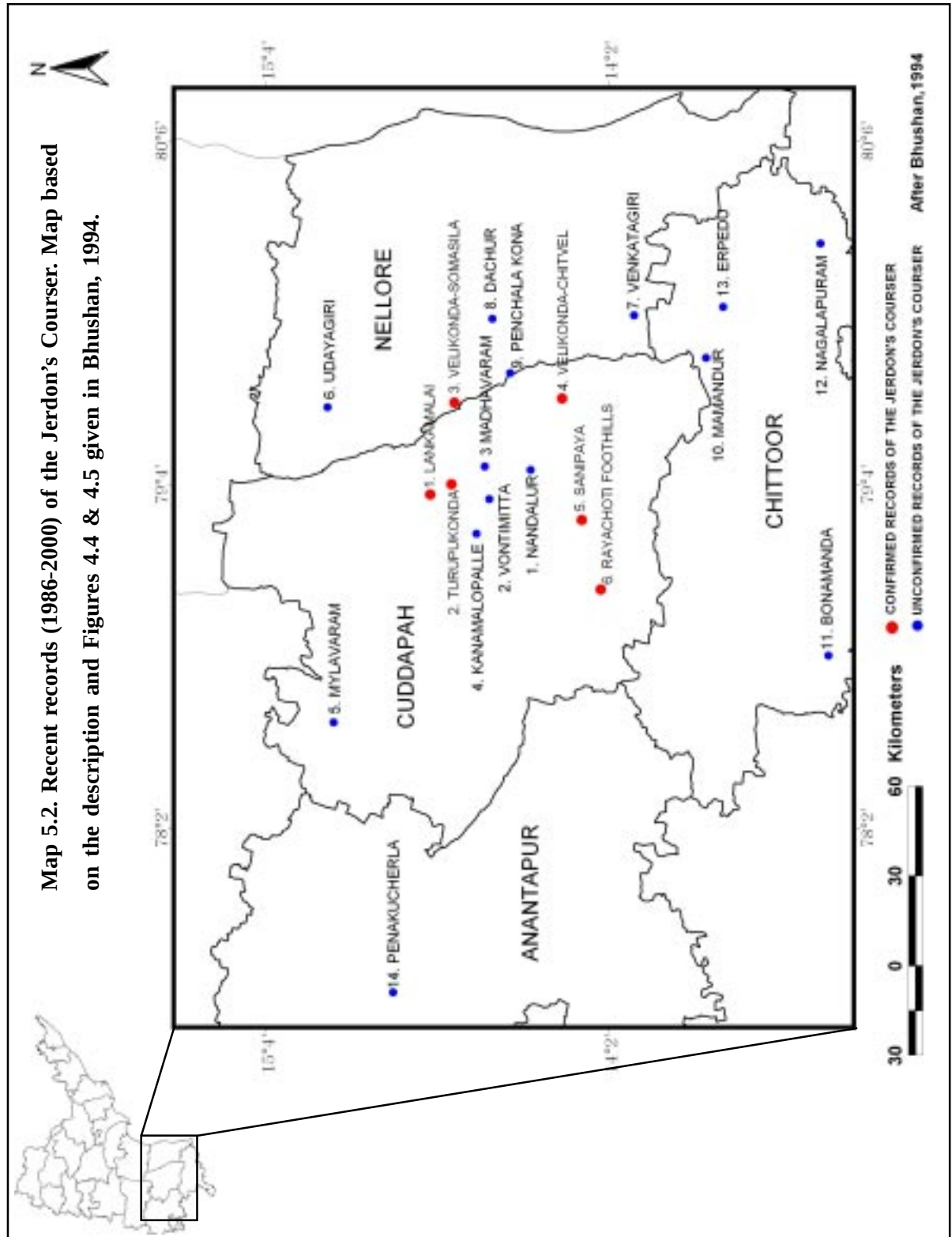
Soon after the rediscovery, survey was conducted mainly in southern Andhra Pradesh that includes Cuddapah, Nellore Chittoor and Anantapur districts (Bhushan 1994). During this survey confirmed reports of the Jerdon's Courser were obtained from six places and it was sighted in two out of these six places. These sight records were only from Cuddapah district. Unconfirmed reports of the Jerdon's Courser were from fourteen places (Map 5.2). It should be noted that except from the places where it has been sighted, reports from other places including confirmed and unconfirmed reports were obtained either from local tribal people or bird trappers. Samant & Elangovan (1997) surveyed in the southern Andhra Pradesh from May 1994 – October 1995 but mainly in and around the Sri Lankamalleswara Wildlife Sanctuary. They noted few more sight records, that too mainly in and around the rediscovery site. There is no record of the Jerdon's Courser from the northern part of the Andhra Pradesh in recent times.

5.2 Study area

The study was conducted in scrub jungle in the Sri Lankamalleswara and Sri Penusila Narasimha Wildlife Sanctuaries, in Cuddapah District, Andhra Pradesh. Major part of the work was carried out in the eastern side of the Lankamalai hill ranges in the Sri Lankamalleswara Wildlife Sanctuary. Tracking strips were placed in the western part of the Turpukonda forest, which is situated in Cuddapah part of the Sri Penusila Narasimha Wildlife Sanctuary also in the western side of the Vellikonda hill ranges. Tracking strips were placed inside as well as out side the Sanctuary. Similarly, tape playback was carried out where ever potentially suitable habitat exists in and around the Sanctuary.

Map 5.1 Historical records of the Jerdon's Courser (1848-1900) (Map not to scale).





5.3 Methods

5.3.1 Identification of scrub jungle habitat using Remote sensing and Geographical Information System (GIS) techniques

Remote sensing and GIS techniques had been widely used for habitat mapping and assessing biodiversity (Nagendra, 2001). Several studies demonstrate that these techniques can be useful to know the distribution and protection status of the habitat, for analyzing land-use/land-cover change in the protected areas, to predict areas of bird endemism, for species distribution modeling and for predicting bird species occurrences (Scott *et al.* 1993, Ramesh *et al.* 1997, Johnson, *et al.* 1998, Osborne *et al.* 2001 and Saveraid *et al.* 2001).

Georeferenced Landsat 7 Enhanced Thematic Mapper (ETM) satellite image of the study area (path/ row 143/050) for December 6, 2000 was used to identify the extent of the scrub jungle habitat in and around Sri Lankamaleswara and Sri Penusila Narasimha Wildlife Sanctuaries. This image was selected because it was acquired during the dry season when most of the landscape features can be clearly seen and the main study area was cloud free. Spatial resolutions of the pixels of this image were 14 m² for the band 8 (panchromatic), 57 m² for 6·1 and 6·2 (thermal bands) and 28·5 m² for the bands 1, 2, 3, 4, 5 and 7. The complete scene covers about 32,400sq/km land area (180 X 180 kms). Most of the part of the Cuddapah and Nellore districts falls within this scene. Small portion of Kurnool, Anantapur, Chittor and Prakasam districts also covered in this image. Subset from this image was taken which includes the recent confirmed records of the Jerdon's Courser as mentioned in Bhushan, 1994. This subset of the image covers 13,200sq/km land area (120 X 110 kms), which includes entire Sri Lankamaleswara Wildlife Sanctuary and most of the western part of the Sri Penusila Narasimha Wildlife Sanctuary (Map 5.3 & Map 5.4) in the Cuddapah Forest Division.

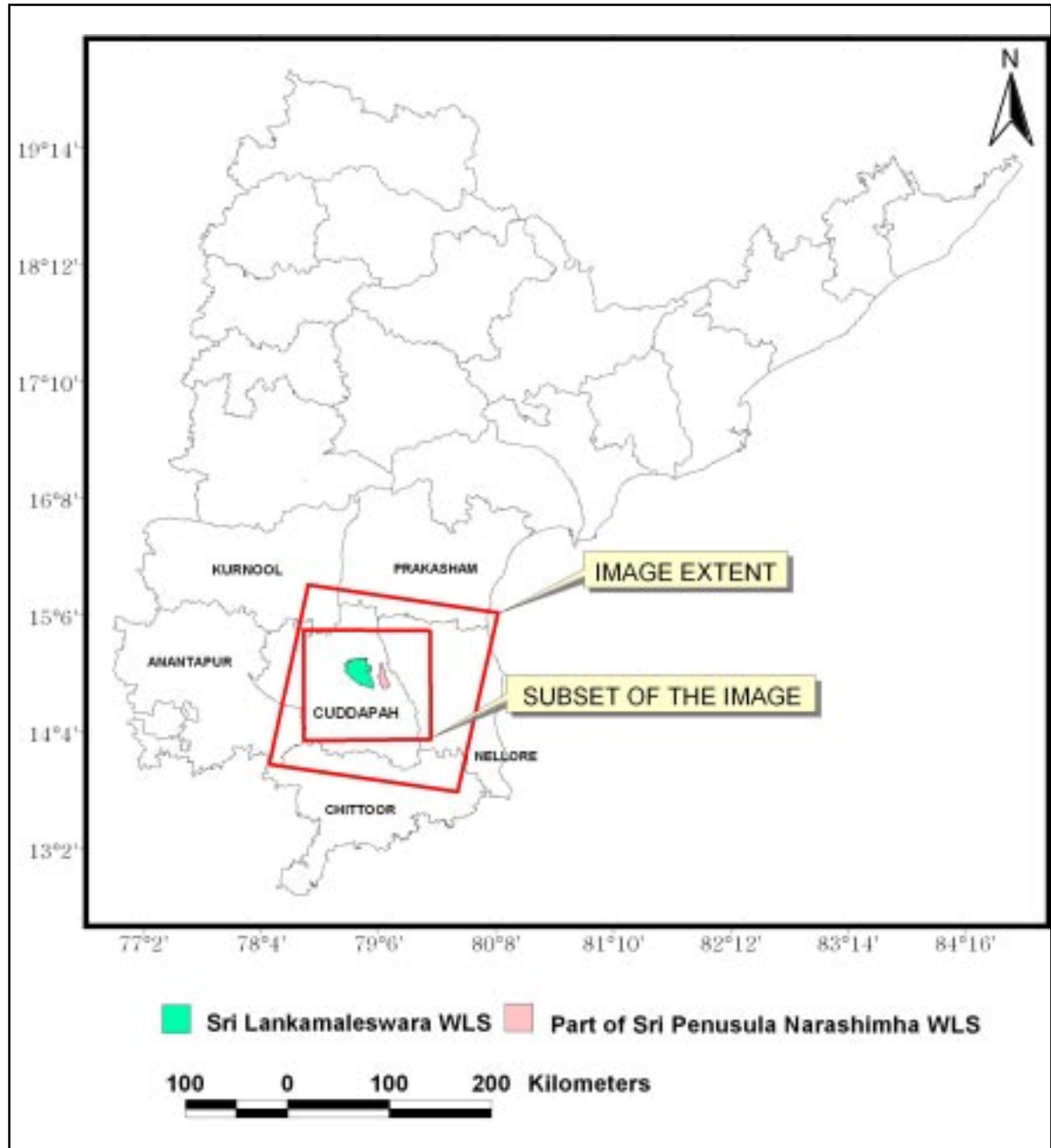
5.3.2 Ground truthing

Ground truthing was carried out initially in and around the main study area and followed by covering larger areas within the subset of the image. The satellite image was visually interpreted

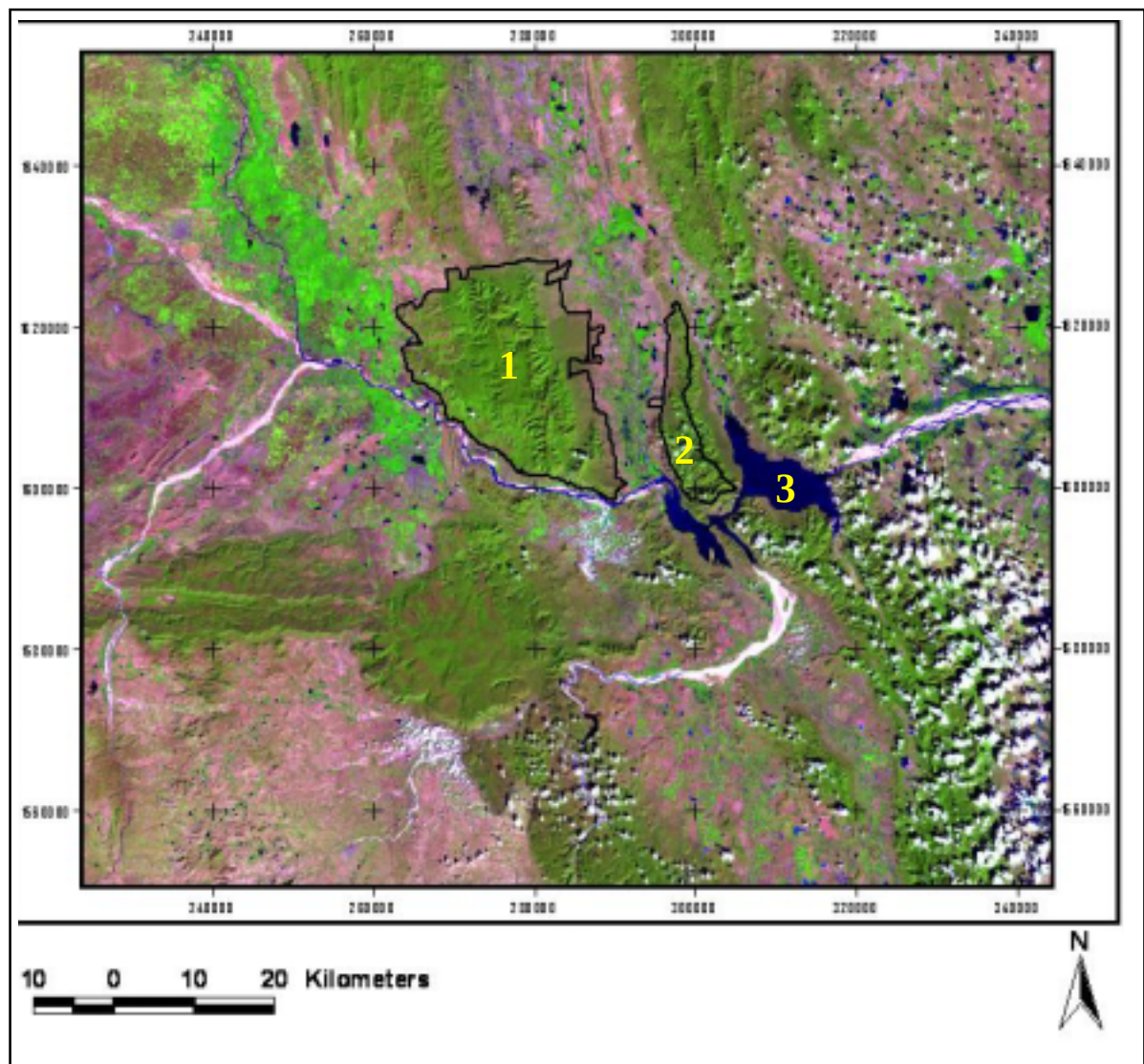
either with the hard copy of the False Color Composite (FCC) with the band combination of 5, 4, 3 or on the digital image displayed on the computer screen. ERDAS Imagine 8.5 software on Windows environment was used for viewing the satellite image on screen. Polygons of different forest types and land covers were chosen randomly from the satellite image. Minimum mapping unit (MMU) was 5 ha. These units consisted of single homogenous vegetation types or land use cover. The co-ordinate of the mid point of that polygon was established by the on screen cursor and it was entered into the GPS as a waypoint. To know the accessibility of the chosen spots, Survey of India toposheets of the study area was referred. On the ground, mid point of the habitat was reached using the GOTO option in the GPS. Interpretation key was prepared based on tone, texture and pattern of the vegetation and land cover types from ground truthing information (Table 5.1). Eight different broad land-use/land-cover categories were established from the ground truthing. Detailed description of these land use categories are as follows:

- Thick forest** – Areas with substantial tree growth with closed canopy cover. Generally located in the hilly region and on top of the hill. Forest areas generally appear green in color in the FCC.
- Scrub** – Areas with dense, sparse scrub vegetation up to 5m in height, with or without open areas. Mainly found in the foothills. This kind of habitat appears mainly purple and sometimes with green and pinkish tinge in the FCC.
- Human habitation** – Urban areas, with a large number of settlements. They appear mainly with speckled purple and white color in the FCC.
- Open areas** – Vast open areas without any vegetation in it or with sparse undergrowth not exceeding more than 1 m in height. These areas are either naturally open or cleared by the people for cultivation. They appear mainly bright pink and sometimes with purplish tinge in the FCC.
- Rocky barren land** – Areas with rocky outcrops, which occurs mainly on top of the hills, sometimes also on the ground. Such areas are not suitable for cultivation. The Rocky barren land appears mainly pale pink along with brown and pale purple in the FCC.
- Water bodies** – Mainly rivers and large tanks. They appear blue in the FCC.

Map 5. 3. Extent of the Landsat Enhanced Thematic Mapper (ETM) 7 satellite image (Path/ Row 143/050) of December 6, 2000 and the subset of the image taken for ground truthing in this study. Sri Lankamaleswara Wildlife Sanctuary and the Cuddapah division of the Sri Penusula Narasimha Wildlife Sanctuary are also shown.



Map 5.4. False Color Composite (Bands 5,4,3) of the subset of the Landsat ETM 7 satellite image taken on 6th December 2000. Boundaries of the Sri Lankamaleswara Wildlife Sanctuary and the Cuddapah division of the Sri Penusula Narasimha Wildlife Sanctuary are also shown. Coordinates are in Universal Transverse Mercator (UTM).



1. Sri Lankamaleswara Wildlife Sanctuary 2. Sri Penusula Narasimha Wildlife Sanctuary
3. Somasilla Reservoir

Sandy areas – Associated with rivers. In the FCC they appears white and sometimes light pink if there is moisture in it.

Agriculture areas – Cultivated areas appears in a regular shape. In the FCC they appears generally green, sometimes in purple and pink mainly due to difference in reflectance values among crops.

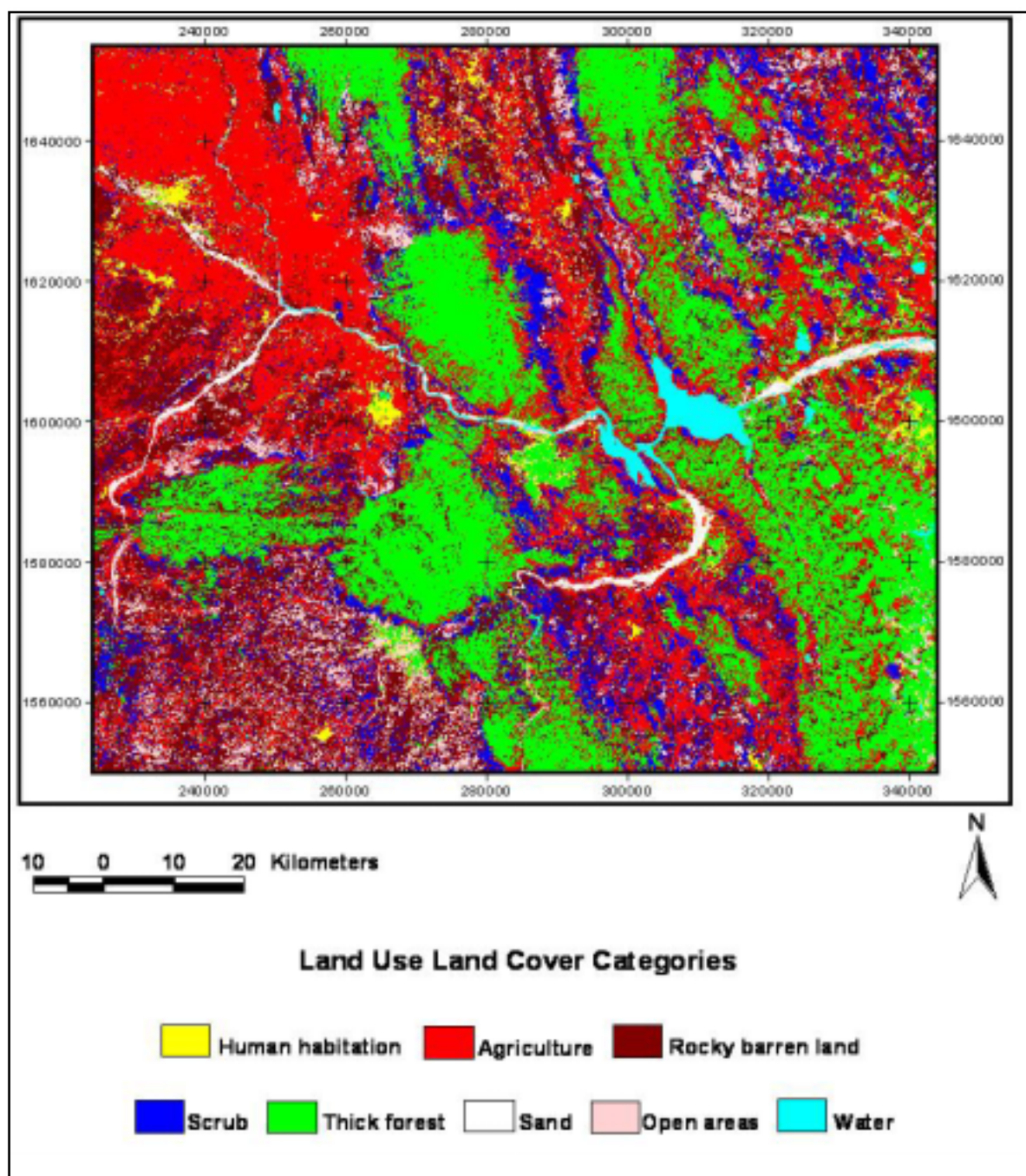
Table 5.1 Interpretation key based on the ground truthing for eight land-use/land-cover categories within the subset of the Landsat ETM 7 satellite image taken on 6th December 2000.

Land cover Type	Tone	Texture	Pattern
Human Habitation	Purple and White	Rough	Irregular
Agriculture	Lime Green, Purple and Pink	Medium To Rough	Regular
Rocky Barren Land	Pale Pink, Brown and Purple	Rough	Irregular
Sand	White and Light Pink	Medium To Rough	Irregular
Scrub	Purple, Green and Pale Pink	Medium To Rough	Irregular
Thick Forest	Green, Bright Green and Pink	Medium To Smooth	Irregular
Water	Dark and Light Blue	Smooth	Irregular
Open Areas	Bright and Pale Pink, Purple	Medium To Rough	Irregular

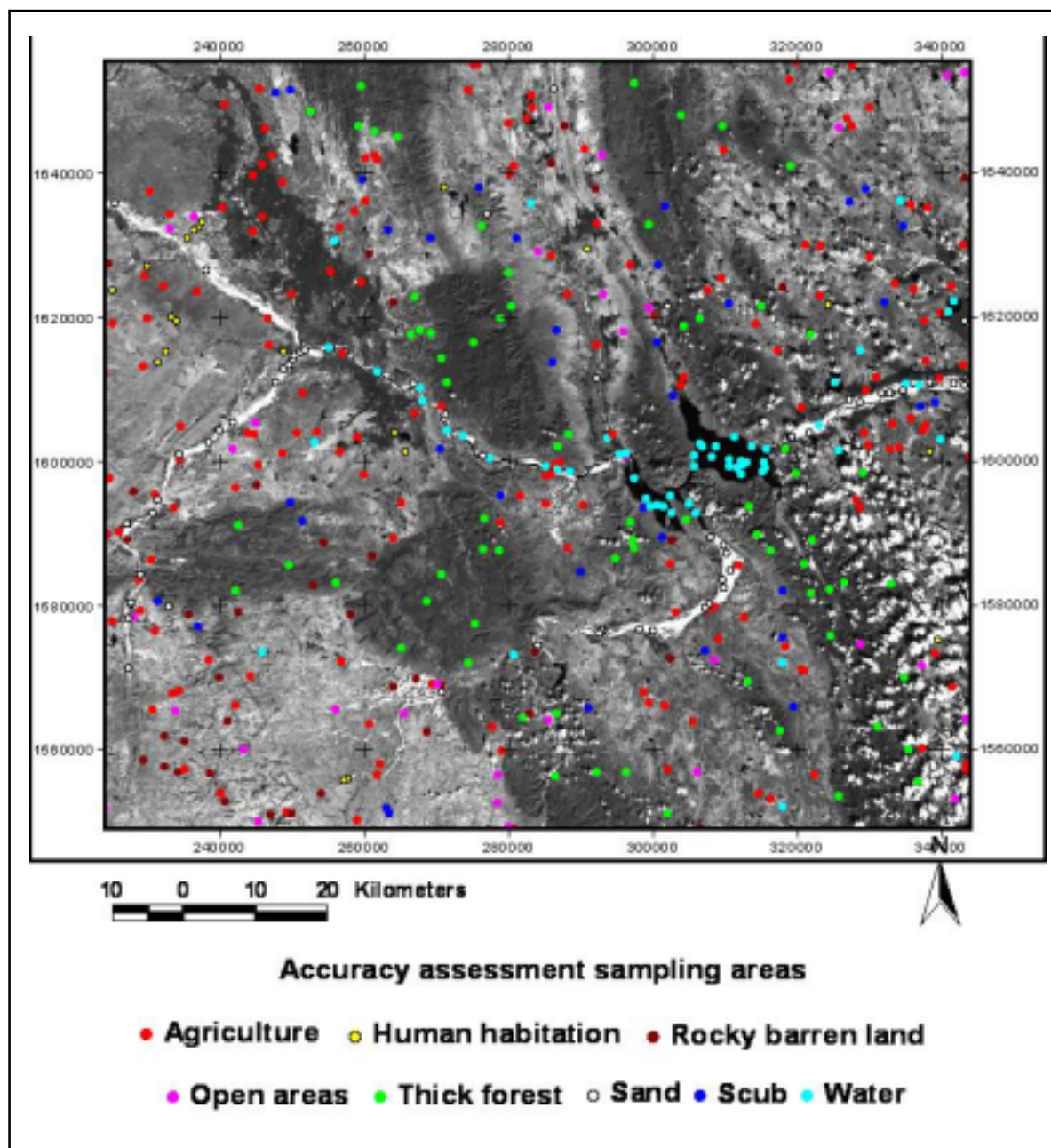
5.3.3 Classification of the satellite image

Image classification was performed using FCC (Band combination - 5, 4, 3 and spatial resolution is 28.5 m²) in ERDAS Imagine 8.5. Initially supervised classification was performed. Training sites of eight land use categories were given on the image in the form of polygons. Homogenous areas with similar spectral characteristics of these categories were identified on the image and polygons were drawn on it as a layer. These layers were used as representative spectral signatures of each land cover categories and the supervised classification was performed to produce the land-use/land-cover map. Since the conventional supervised classification allocates each image pixel to a land cover category, it generally will have a speckled output and can reduce the overall classification accuracy, however this can be overcome by fuzzy classification (Foody, 1996). Supervised classification output was placed in the fuzzy convolution utility of the software for spatial filtering by passing a 3 X 3 window over the image to create a new output land-use/land-cover map (Map 5.5). This will result in creating a context-based classification to reduce the speckle in the classification (Pouncey *et al*, 1999).

Map 5.5. Classified output map of the subset of the Landsat ETM 7 satellite image taken on 6th December 2000. Eight different Land-use/Land-cover categories shown in different colors. Coordinates are in Universal Transverse Mercator (UTM).



Map 5.6. Distribution of the five hundred ground truthing stratified random points in the subset of the Landsat Enhanced Thematic Mapper 7 satellite image (Path/ Row 143/050) of December 6, 2000. Image shown in gray scale. Coordinates are in Universal Transverse Mercator (UTM).



5.3.4 Assessment of the classification accuracy

To determine the quality of the information derived from the remotely sensed data, accuracy assessment was carried out. Stratified random samples of 500 points were generated for eight land-use/land-cover categories using Accuracy Assessment program in ERDAS Imagine software (Map 5.6). These points were loaded into the GPS and ground truthing was repeated again. Ground checking was carried out wherever it is accessible. It was done mainly for scrub, agriculture areas, rocky barren land, thick forest and open areas. For waterbodies, sand and human habitations, it was checked in the FCC on the screen itself. Identity of some of the points, which are inaccessible, were confirmed with Survey of India toposheets and also through *a priori* knowledge of the spectral signatures gathered from the previously conducted ground truthing. This ground truth information then compared against the classified output map to generate user, producer and overall classification accuracy as well as Kappa statistics ($K^{\wedge}$) were calculated.

5.3.5 Calculation of the extent of scrub jungle habitat

Protection status and the extent of scrub jungle habitat in and around Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries were calculated from the classified land-use/land-cover maps. For achieving this, a polygon was drawn covering the Sri Lankamaleswara Wildlife Sanctuary and part of the Sri Penusula Narasimha Wildlife Sanctuary, which falls in Cuddapah Forest Division and this area, was cropped from the main subset of the classified image. In order to obtain the area information of the image pixels, Raster format of the classified image has to be converted into vector format. So, the Raster image of this area of interest was converted as a vector layer. Boundaries of the two protected areas were kept as a overlay on the newly generated vector layer and it was clipped using the Geo-processing option in the ArcView 3.2a GIS software to know the amount of pixels classified as scrub falls in and around the two protected areas. Since some of the areas found inside and outside the sanctuaries that are not scrub were classified as scrub, care was taken to exclude those areas by referring the FCC and classified land-use/land-cover map. From the attributes tables of these vector layers, pixels, which are classified as scrub was sorted and area obtained.

5.3.6 Tracking Strip survey

Having developed the tracking strip method and the diagnostic method to identify the tracks of the bird footprints, surveys were conducted to locate the Jerdon's Courser in new areas by following these methods (detail account of the tracking strip method discussed in Chapter 3). Tracking strips were deployed from 2001 to 2003 in 23 blocks of scrub jungle. Within each of these blocks, strips were placed on a square grid with 50 m or 100 m spacing. Number of tracking strips differ in each blocks differs from 12 to 20. The grids were laid out within irregularly shaped areas of apparently suitable habitat using a GPS. Each strip was placed as near as possible to the place specified by the grid, but a few strips were displaced by a few meters if the specified place coincided with a large bush or tree. Apart from these necessary displacements, strips were deployed at random with respect to habitat within all blocks. Tracking strips were checked at intervals of 4 days (range 1-7 days).

Initially, tracking strips were placed randomly in the known Jerdon's Courser area (JC1 & JC2). It is discussed in Chapter 3 in detail and the information gathered from this survey was not used in this chapter because it was a preliminary study conducted mainly to know the tracking rate of the Jerdon's Courser and not meant for distribution survey. In that survey tracking strips were not placed in regular square grid. Apart from this reason the Jerdon's Courser was known to occur in this place regularly from 1986 and the objective of this study was to detect them in new areas. However, three blocks of tracking strips were placed in and around the known Jerdon's Courser areas as well in a regular square grid. This information is included in this chapter since these blocks covers areas well outside the known Jerdon's Courser area.

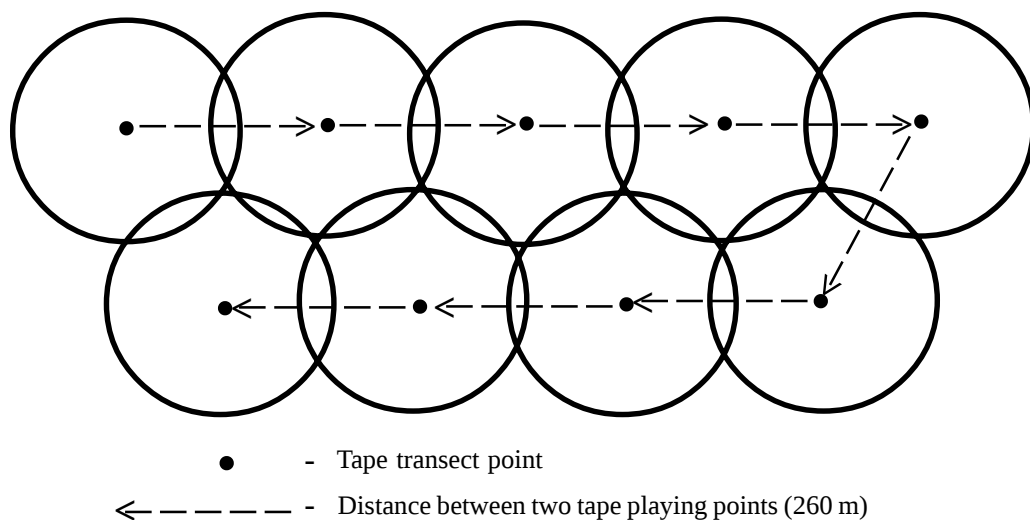
From the estimate of the tracking rate in the main Jerdon's Courser area, it was calculated that if survey is carried out in an area using more than 458 strip-nights then there would be less than 1% of being incorrect in concluding that the Jerdon's Courser is absent in a particular area (during the survey). . Therefore, tracking strips were monitored in all the blocks to meet this level of effort. If the Jerdon's Courser track was obtained even before completing this effort (i.e. 458 strip-nights), survey was discontinued and camera traps were deployed to further confirm the presence

of the Jerdon's Courser. However, in some blocks, monitoring the tracking strips were continued well beyond the optimal survey effort to ascertain the habitat selection of the Jerdon's Courser and in some blocks survey was not conducted up to 458 strip-nights due to rain and logistical constraints.

5.3.7 Tape playback survey

Tape transect survey method was devised to find the Jerdon's Courser in new areas. Initially, tape playback was carried out at known Jerdon's Courser areas to know the rate at which it responded to its own call (see Chapter 4). Tape transects involve, playing a standard one minute duration tape loop cassette with 4 bouts of calling, each of 10 calls at c. 1 second intervals, each bout separated by 5 seconds of silence, from a fixed point in scrub jungle. This tape was played for one minute at each place, on a double-speaker portable cassette player. The tape was played in all the directions for each bout of ten calls. The observer then listened for a minute before moving on to another point. The bearing, range and duration of calling by Jerdon's Courser were recorded. Points at which tapes are played were arranged on a regular grid with 260 m spacing. This design ensured that no point in the surveyed area was more than 150 m from a tape playing places (Figure 5.1). Tape transects began 45 minutes after sunset and continued for 45-50 minutes. Survey was not conducted during inclement weather conditions. Tape transect survey was carried out from March 2002 to November 2003.

Figure 5.1 Diagrammatic representation of the Tape Transect design.



5.4 Results

5.4.1 Classification accuracy

Of the eight land cover categories only water and sand were classified with 100% users accuracy (calculated by dividing the number of correct pixels for a category by the total pixels assigned to that category) while the producers accuracy (calculated by dividing the number of correct pixels for a category by the actual number of ground truth pixels for that category) for these two categories being 86.44% and 79.37 % respectively. Overall classification accuracy was 65% and overall Kappa ($K^{\wedge}$) = 0.5948 (Table 5.2). Error of commission (i.e. pixels incorrectly assigned to a particular land use category that actually belong in other category) was higher for agriculture areas, while major part of the pixels belonging to this category incorrectly were excluded (error of omission) and falls in thick forest (Table 5.3). As far as the scrub jungle category is concerned, user and producer accuracy was 55% and 91.67 % respectively. Error of omission for the scrub jungle pixels is 45% and the major part of this was in agriculture. Details of use and producer accuracy, error of commission and omission for other land use categories can be seen in Table 5.3 & Table 5.4.

5.4.2 Extent of scrub jungle habitat

Total area classified as scrub in and around the Sri Lankamaleswara Wildlife Sanctuary was 8,786 ha. Majority of this area found in a narrow strip mainly in the eastern part of Sri Lankamaleswara Wildlife Sanctuary. The largest continuous patch of scrub in this area measured

Table 5.2. Kappa ($K^{\wedge}$) Statistics for the eight-land use land cover categories of the classification of the subset of the Landsat Enhanced Thematic Mapper 7 satellite image taken on 6th December 2000. 1* indicates 100% accuracy.

Land Use Land Cover Categories	Kappa	Users Accuracy	Producers Accuracy
Human Habitation	0.3389	0.3654	0.95
Agriculture	0.6457	0.7683	0.3642
Rocky Barren Land	0.3056	0.3611	0.65
Sand	1*	1*	0.7937
Scrub	0.5151	0.55	0.9167
Thick Forest	0.7375	0.7763	0.7973
Water	1*	1*	0.8644
Open Areas	0.3775	0.4211	0.6857
Overall Kappa Statistics = 0.5948			

Table 5.3. Error matrix of the accuracy assessment of the eight classified land-use/land-cover categories in the subset of the Landsat Enhanced Thematic Mapper 7 satellite image taken on 6th December 2000.

Land Use Land Cover Categories	Human Habitation	Agriculture	Rocky Barren Land	Sand	Scrub	Thick Forest	Water	Open areas	Row Total
Human Habitation	19	24	3	0	0	0	5	1	52
Agriculture	1	63	2	1	2	13	0	0	82
Rocky Barren Land	0	29	26	2	1	2	3	9	72
Sand	0	0	0	50	0	0	0	0	50
Scrub	0	22	4	1	33	0	0	0	60
Thick Forest	0	14	2	0	0	59	0	1	76
Water	0	0	0	0	0	0	51	0	51
Open Areas	0	21	3	9	0	0	0	2	57
Column Total	20	173	40	63	36	74	59	35	500

was 2,492 ha and most of the part of this patch falls in Yerraballi Forest Block and also extending outside the Sanctuary area. Nearly 2,000 ha of scrub jungle habitat is present outside the Sanctuary limits. Extent of Scrub jungle habitat around the western part of the Sri Peninsula Narasimha Wildlife Sanctuary, which comes under Cuddapah Forest Division, is 1,665 ha and the largest patch of scrub was 401 ha. This patch falls partially inside the Muthukuru Forest Block. There are very few large patches of scrub found in this part of the Sanctuary (Table 5.5, Map 5.7). It should be noted that the number of patches for both these sanctuaries in less than 5 ha category was higher mainly because, these are the values either from single pixel or clusters of small patches distributed discontinuously. These values are not excluded since visual scanning of the vector layer reveals that most of these pixels and small patches were adjacent to the large scrub patches. However many of such patches present well outside the Sanctuary areas were removed manually on the screen by comparing the FCC of the image.

Table 5.4. Percentage of User and Producers Accuracy of the eight-land-use/land-cover categories of the classification of the subset of the Landsat Enhanced Thematic Mapper 7 satellite image taken on 6th December 2000.

Land Use Land Cover Categories	Reference Total	Classified Total	Number Correct	Users Accuracy (%)	Producers Accuracy (%)
Human Habitation	20	52	19	36.54	95
Agriculture	173	82	63	76.83	36.42
Rocky Barren Land	40	72	26	36.11	65
Sand	63	50	50	100	79.37
Scrub	36	60	33	55	91.67
Thick Forest	74	76	59	77.63	79.73
Water	59	51	51	100	86.44
Open Areas	35	57	24	42.11	68.57
Totals	500	500	325		
Overall Classification Accuracy = 65%					

Map 5.7 Distribution and extent of scrub jungle in and around Sri Lankamaleswara & Sri Penusula Narasimha Wildlife Sanctuaries, Cuddapah District, Andhra Pradesh. Scrub Jungle area categories were also given.

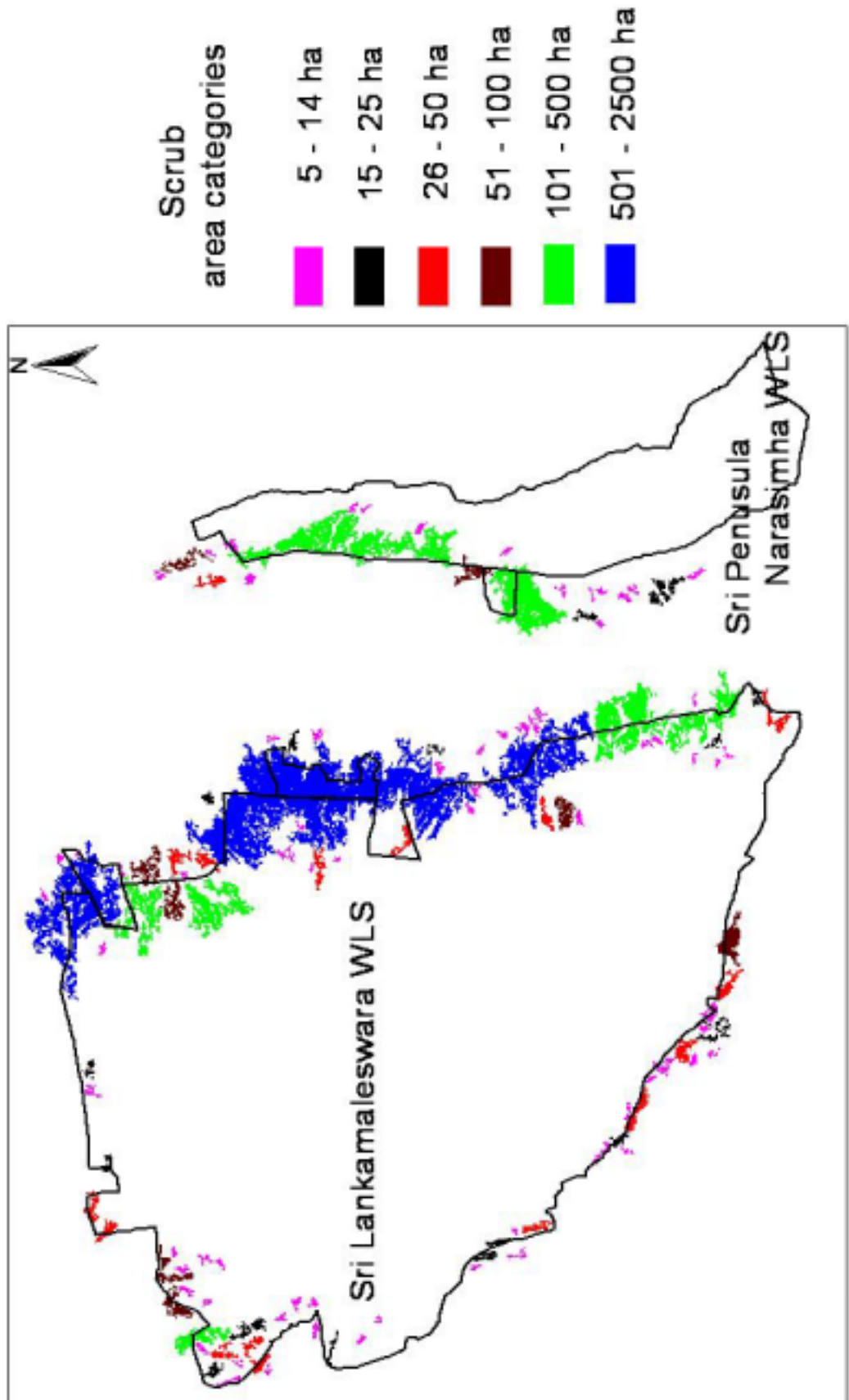


Table 5.5. Details of area categories and total area of the scrub jungle habitat classified in the land-use/land-cover map in and around the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries.

Area categories of the Scrub jungle habitat patches	Sri LankamaleswaraWLS		Sri Penusula NarasimhaWLS	
	No. of patches	Total area (ha)	No. of patches	Total area (ha)
<5 ha	1679	992	421	259
5-14 ha	65	544	15	128
15-25 ha	18	348	4	86
26-50 ha	16	560	1	31
51-100 ha	6	425	2	110
101-500 ha	10	2012	3	1052
501-2500 ha	3	3904	0	0
Grand Total	1797	8786	446	1665

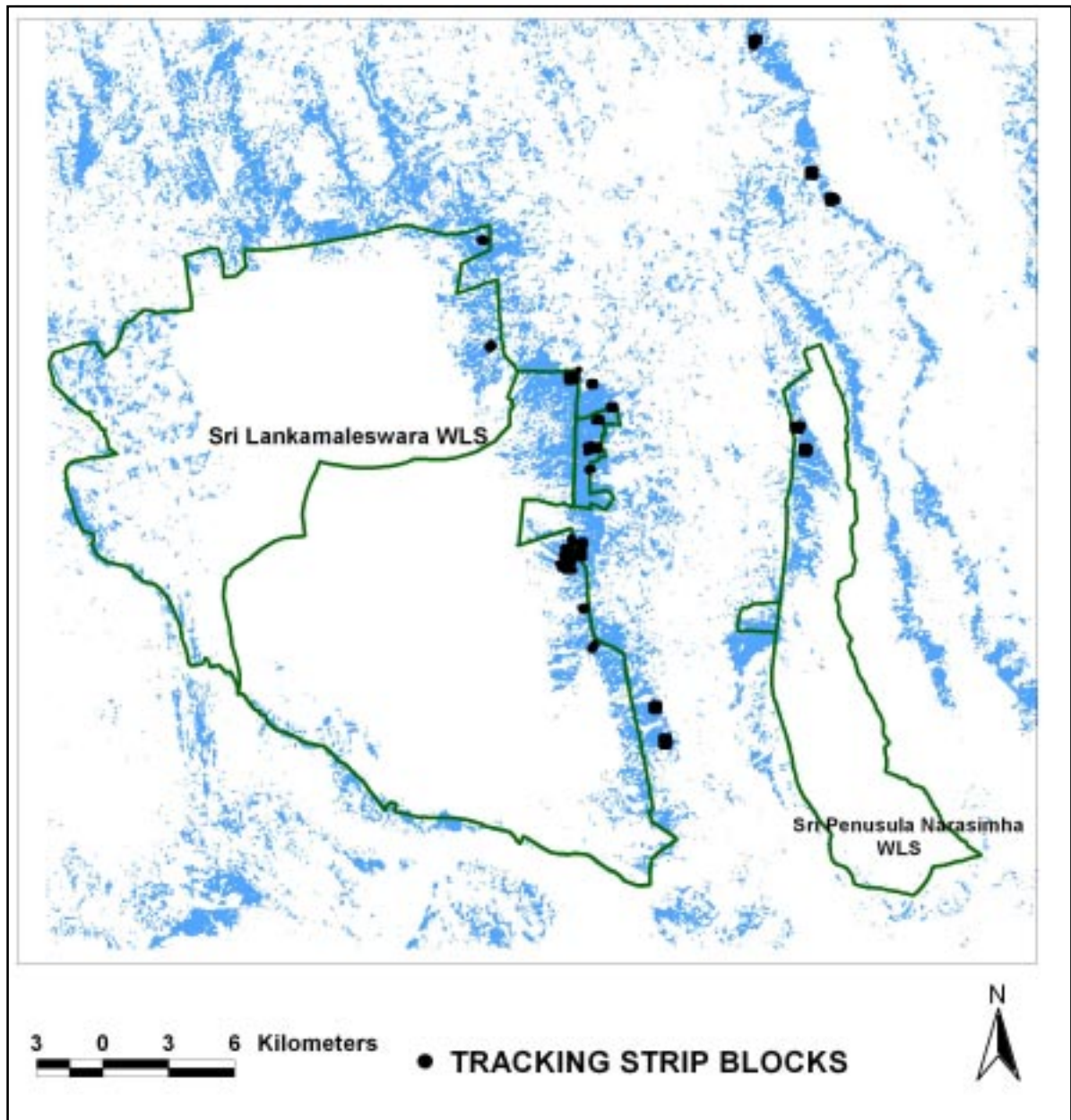
5.4.3 Selection of survey locations

Classified land-use/land-cover map was used to identify the scrub jungle habitat in and around the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries. It should be noted that in the land-use/land-cover map scrub jungle habitat was classified irrespective of whether it is thick scrub, scrub with open areas, sparse scrub and also areas where there was more *Prosopis juliflora*, an invasive plant that grows up to 4-5 m in height. So, survey was conducted mainly in the places, which looks superficially similar in terms of scrub height (c.3-4m in height) and the association of the scrub species found in the main Jerdon's Courser areas where it has been seen regularly.

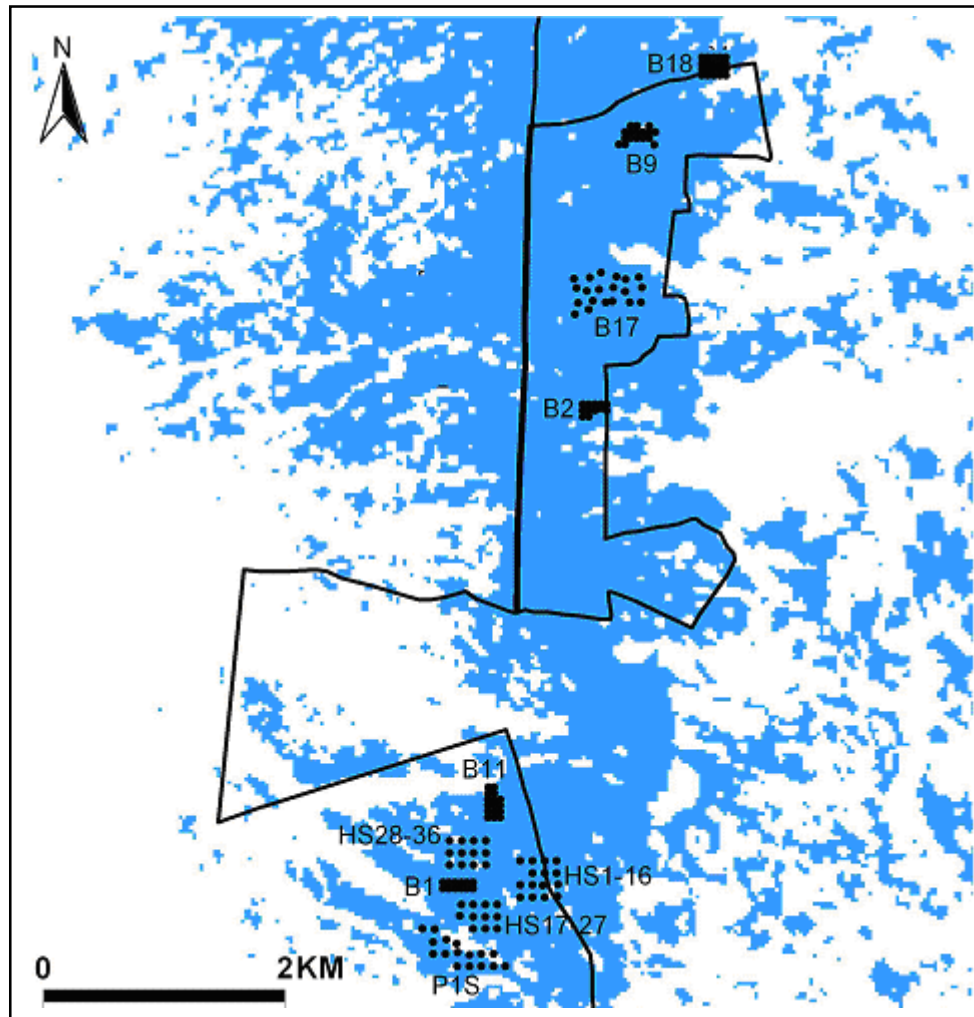
5.4.4 Detection of Jerdon's Courser through tracking strip survey

Totally 392 tracking strips were deployed in 23 blocks and total tracking strip nights was 9,951. Area covered by all these blocks was 180 ha. All of these blocks were surveyed once except for one block (HS 17-27), which was surveyed in 2002 and 2003. Two blocks (B4 & B10) were in Sri Penusula Narasimha Wildlife Sanctuary, three blocks were in the reserve forest areas of Vellikonda Hill ranges. Rest of all the other blocks were deployed in and around Sri Lankamaleswara Wildlife Sanctuary (Map 5.8 & Map 5.9). Survey was conducted mainly during the dry season (December to May), however rain destroyed the tracking strips in 7 blocks, which are redeployed immediately during the survey period. Apart from this, several tracking strips were destroyed by cattle, goats and human tracks so, it necessitated redeployment.

Map 5. 8. Distribution of the 23 tracking strip blocks deployed in and around Sri Lankamaleswara Wildlife Sanctuary and the Cuddapah division of the Sri Peninsula Narasimha Wildlife Sanctuary. Blocks overlaid on the classified map, which shows the scrub jungle habitat. Tracking strip blocks of main Jerdon's Courser area and Yerraballi Forest Block comes inside the box shown. Expanded view of this area can be seen in Map 5.9.



Map 5.9 Tracking strip blocks deployed in the main Jerdon's Courser area and Yerraballi Forest Block.



Footprints of Jerdon's Courser were recorded on a total of 14 tracking strips in 6 of the 23 blocks (Table 5.6, Map 5.10). These are new localities for Jerdon's Courser. Three of the blocks (HS 1-6, HS 17-27 & HS 28-39) with new records were within 1 km of previously known site (JC1 & JC2), the other three were (B3, B9 and B6) were 4, 7 and 15 km away. All these records were only from Sri Lankamaleswara Wildlife Sanctuary, and none from Sri Penusula Narasimha Wildlife Sanctuary.

Map 5. 10. Jerdon's Courser tracks records in and around the Sri Lankamaleswara Wildlife Sanctuary.

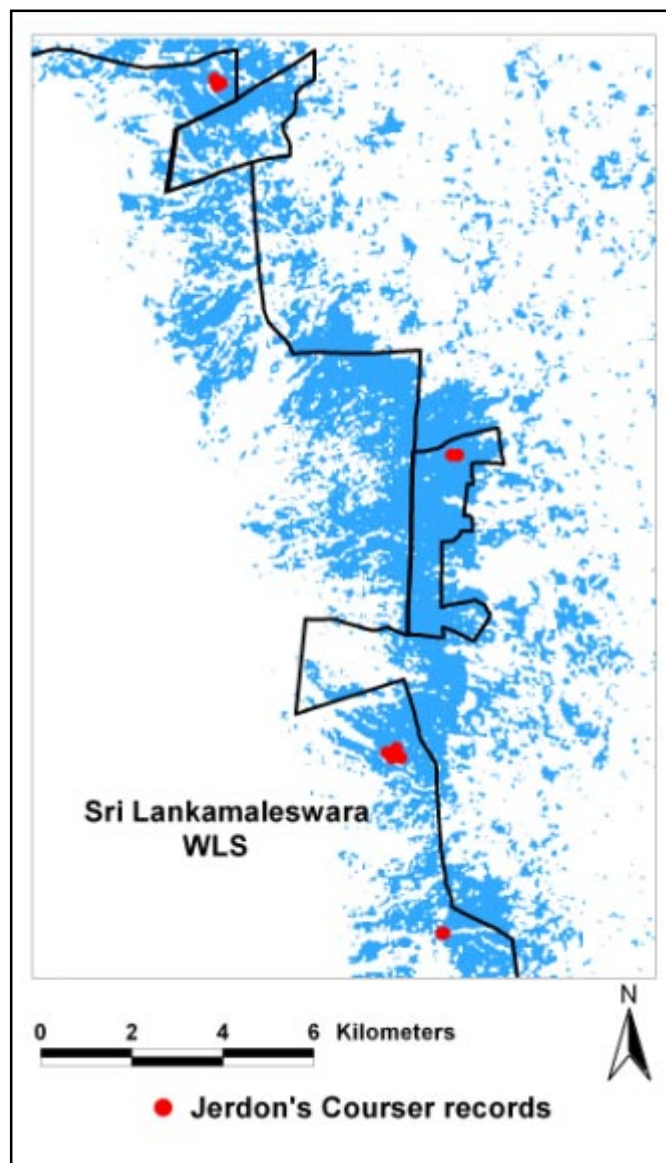


Table 5.6 Deployment of tracking strips and records of tracks of Jerdon's Courser in the 23 blocks shown in Map 5. 9& 5.10. Note that Block HS 17-27 surveyed twice and the blocks and records from where the Jerdon's Courser tracks obtained shown in bold letter. * indicates blocks where the tracking strips place in 50 m square grid.

Sl. No.	Year	Block	First strip deployed	Last check	No. of strips	Strip nights	Jerdon's Courser tracking events	Strips with Jerdon's Courser tracks	No. of times redeployed	Area covered (ha)
1	2001	P1S	25-Apr-01	6-Jun-01	16	421	0	0	1	10
2	2001	B1*	9-Dec-01	19-Dec-01	12	112	0	0	0	2
3	2001-2002	B2*	6-Dec-01	21-Feb-02	12	477	0	0	3	2
4	2001-2002	B5*	7-Dec-01	21-Feb-02	14	458	0	0	2	3
5	2001-2002	B3*	8-Dec-01	20-Feb-02	16	477	3	2	2	4
6	2001-2002	B9*	9-Dec-01	18-Feb-02	17	435	3	2	3	5
7	2002	B6*	15-Feb-02	6-Mar-02	14	231	3	3	0	3
8	2002	B11*	19-Feb-02	28-Mar-02	16	555	0	0	0	3
9	2002	HS 1-16	27-Feb-02	4-May-02	15	756	1	1	1	11
10	2002	HS 17-27	8-Apr-02	24-May-02	11	334	4	4	1	7
11	2002	HS 28-39	11-Apr-02	3-May-02	12	247	1	1	0	7
12	2002-2003	B8	3-Dec-02	9-Jan-03	20	499	0	0	0	13
13	2002-2003	B4	4-Dec-02	5-Jan-03	16	459	0	0	0	12
14	2002-2003	B7	4-Dec-02	9-Jan-03	20	460	0	0	0	11
15	2002-2003	B13	5-Dec-02	11-Jan-03	16	462	0	0	0	11
16	2002-2003	B14	15-Dec-02	14-Jan-03	19	454	0	0	0	11
17	2002-2003	B10	15-Dec-02	9-Jan-03	20	387	0	0	0	10
18	2003	B12	7-Feb-03	10-Mar-03	16	484	0	0	0	11
19	2003	B15	9-Apr-03	9-May-03	20	471	0	0	0	15
20	2003	HS 17-27	10-Apr-03	23-May-03	10	350	0	0	0	
21	2003	B18*	12-Apr-03	9-May-03	20	465	0	0	0	4
22	2003	B17	14-Apr-03	18-May-03	20	512	0	0	0	15
23	2003	B19*	8-May-03	26-May-03	20	238	0	0	0	5
24	2003	B20*	9-May-03	26-May-03	20	207	0	0	0	5
TOTAL					392	9951	15	13	13	180

5.4.5 Camera trapping

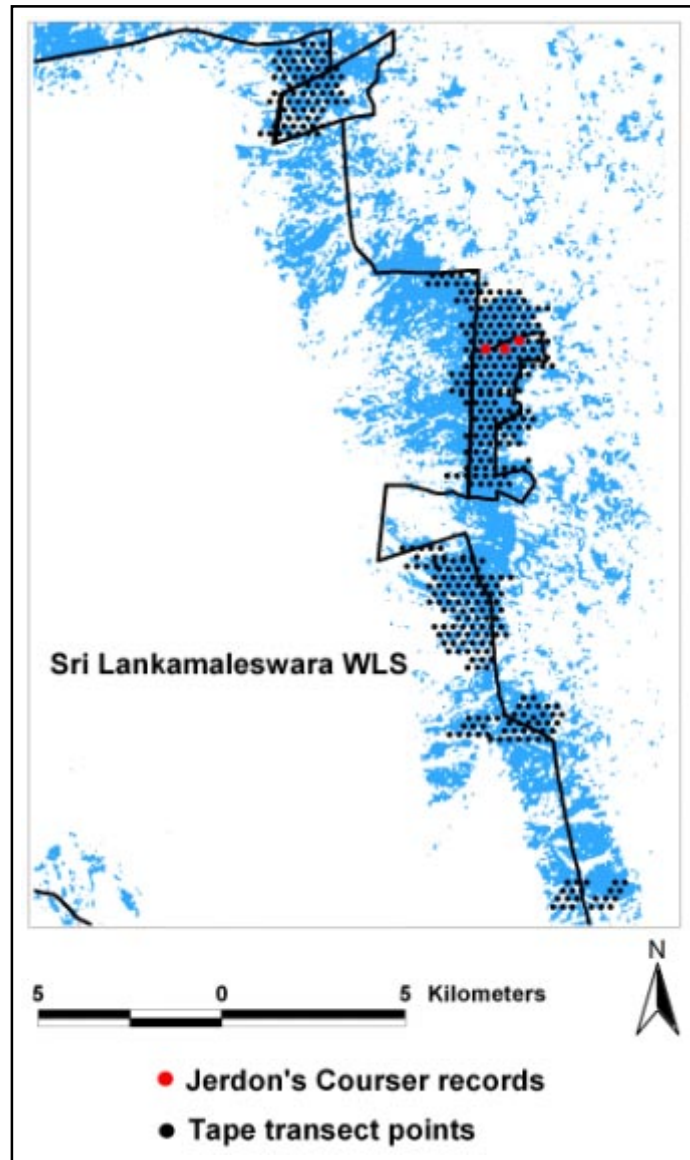
As soon as tracks of the Jerdon's Courser were obtained in two blocks (B3 & B9), camera traps were installed from 18th December 2001 to 15th February 2002 in 29 places within the blocks. Camera traps were either coincides with or without tracking strips in a regular square grid. Excluding a few nights on which the triggering devices malfunctioned and disturbed by cattle and other wild animals, the camera operated for 59 camera nights (7 in B3 and 52 in B9). However, no photograph of the Jerdon's Courser was obtained.

5.4.6 Detection of Jerdon's Courser through tape playback survey

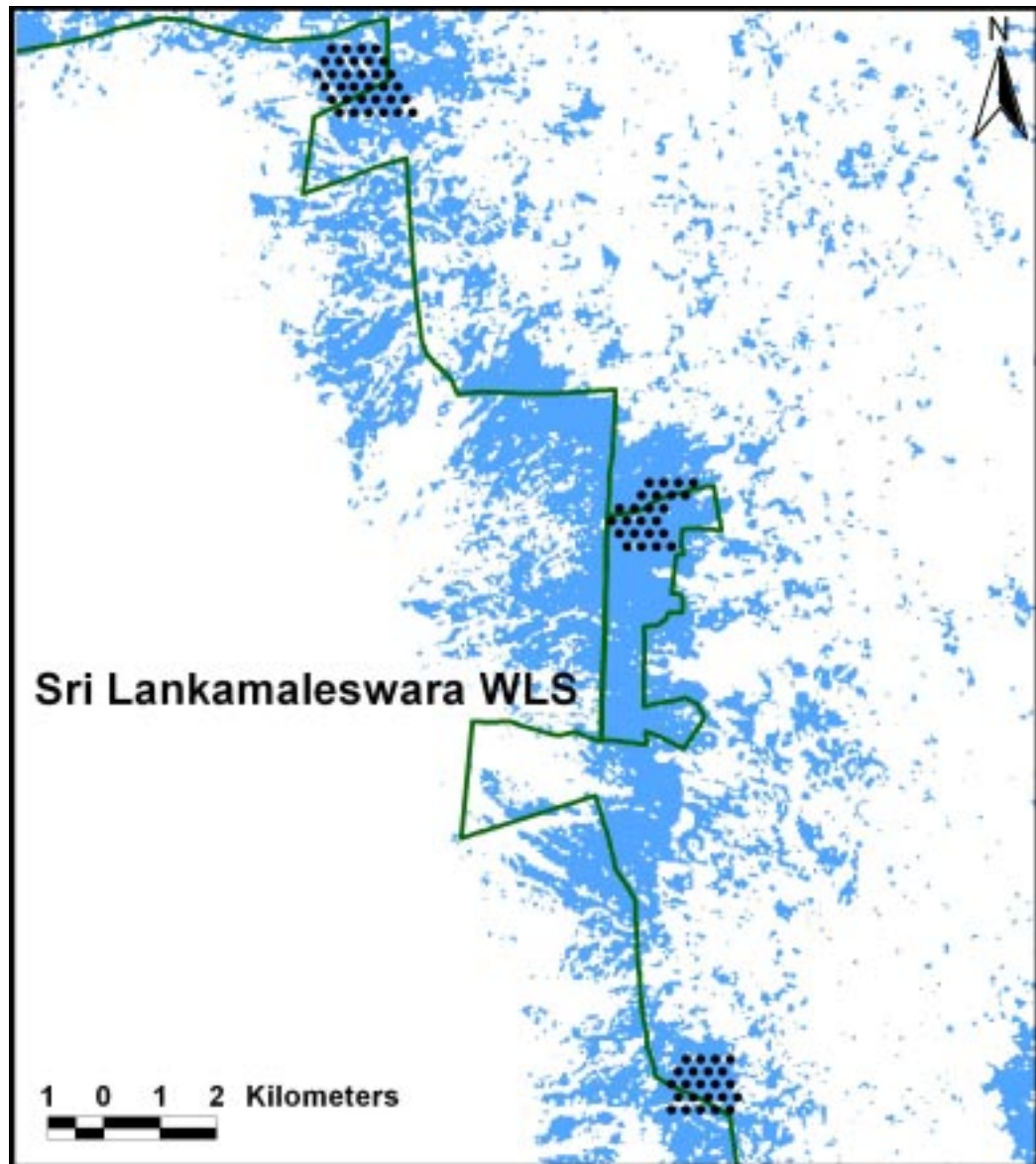
Tape transect survey was carried out mainly in the eastern part of the Sri Lankamaleswara Wildlife Sanctuary. Almost the entire scrub jungle area of this part was covered by the tape transect survey. Totally tape was played in 403 points. Total area covered was measured by plotting the tape transect points in the ArcView 3.2a GIS software and buffer was created for 260 m from the center of the peripheral tape transect points. Then area was obtained by drawing a polygon around the margin of the buffer. Total area surveyed by the tape transect method was 2,132 ha. Each point was surveyed only once from March 2002 to February 2003. Survey was not conducted from August 2002 to January 2003. Out of this 403 tape play points, Jerdon's Courser call was elicited in 3 points in June 2002 (Map 5.11). These points were around the block (B9) where the Jerdon's Courser tracks were detected in December 2001. Jerdon's Courser calls were not heard or elicited response for tape-playback in any other points surveyed.

Apart from this effort, tape transect survey was carried out every month regularly from March to November 2003 in three blocks (B3, B6 & B9) where the Jerdon's Courser was detected by means of tracks. Tape play points were arranged encompassing the areas where the tracks were seen (Map 5.12). In B9 area, the points where arranged around the tracking strips where the Jerdon's Courser tracks seen as well as the points where the calls elicited was also surveyed repeatedly from April to November 2003. It should be noted that three points in B9 area (B9JC1, B9JC2 & B9JC3) had been monitored regularly ever since the Jerdon's Courser calls elicited in June 2002. This monitoring was continued till March 2003 and the information collected

Map 5.11. Tape Transect points and Jerdon's Courser records.



Map 5.12. Tape transect points surveyed regularly from March to November 2003 in and around three blocks from where the Jerdon's Courser tracks obtained. Black dots indicates each tape transect points played.



during this period was analyzed in Chapter 4. However, this information was not used here because, it was done mainly by visiting those particular points for call listening and tape playback but surrounding areas were not surveyed and it was not systematic. Twenty-three points were surveyed in B3 covering an area of 201 ha and in B6 & B9 there were 32 and 24 points covering 270 and 218 ha respectively. Survey was not conducted during August 2003 in B6 and in other blocks tape was played in very few points due to inclement weather. (Table 5.7). Totally tape was played in 79 points in three blocks for combined total of 554 times. Average number of tape play in each point is 6.8 (range 4 - 9) and only 6 points were surveyed for five times or less. Calls of the Jerdon's Courser were not heard, nor are playback elicited any response.

Table 5.7 Details of the Tape transect points surveyed in 3 blocks from March-November 2003.

Year 2003	B3	B6	B9	Grand Total
March	23	32	-	55
April	22	31	24	77
May	23	29	15	67
June	23	9	19	51
July	23	30	8	61
August	8	-	7	15
September	23	31	24	78
October	23	25	24	72
November	23	32	23	78
Grand Total	191	219	144	554

5.5 Discussion

5.5.1 Current geographical distribution of the Jerdon's Courser

Historically Jerdon's Courser had been reported only from Andhra Pradesh. Soon after the rediscovery it has been reported in twenty places (Bhushan, 1994). However it was actually sighted only in two places. Rest of the records were obtained by interviewing either tribal or bird trappers. Uncertainty of the night search method to detect the Jerdon's Courser was discussed in Chapter 3 in detail. Following the newly developed survey methods (tracking strips and tape transect methods) in this study, the presence of the Jerdon's Courser was established in three new places in the eastern part of the Sri Lankamaleswara Wildlife Sanctuary. Apart from that, it has

been detected in two more places, which are within 1 km from the main known Jerdon's Courser area. It should be noted that although the Jerdon's Courser was detected in three new places, frequency of occurrence was higher only in and around the main Jerdon's Courser area. So, it can be concluded here that the current authentic known geographical distribution of the Jerdon's Courser is only in and around the eastern part of Sri Lankamaleswara Wildlife Sanctuary.

5.5.2 Evaluation of methods to detect the presence of the Jerdon's Courser

Detailed assessment of tracking strip and tape transect methods were discussed in Chapter 3 & 4. It can be emphasized here that tracking strip method would be the best way to know the distribution of the Jerdon's Courser. Although the tracking strip method is labour intensive and also it may not be possible to cover larger area compared to tape transect survey, it is still a better way to detect the presence as well as the absence of the Jerdon's Courser. It has potential to study habitat selection of the Jerdon's Courser as well. Tape transect and call listening survey can be followed in a smaller areas where the rate of detection is higher and it can also be useful to estimate the relative abundance and density if the tape playback survey is combined with radio-telemetry studies.

5.5.3 Classification of the scrub jungle habitat

Although the over all accuracy for the classification was 65 %, user accuracy for the scrub jungle habitat was not very high (55%) and several agricultural areas were misclassified as scrub. In the land-use/land-cover map in dense scrub, scrub with open areas and sparse scrub were shown as one category. It was observed while doing the ground truthing association of the scrub species differs from place to place. In fact, the type of scrub jungle with open areas found in the eastern part of the Sri Lankamaleswara Wildlife Sanctuary, with the association of scrub and tree species such as *Carissa carandas*, *Maytenus emarginata* and *Hardwickia binata* was seen in very few places within the subset of the image during the ground truthing survey. Apart from that, it was noticed that areas where there are more *Prosopis juliflora*, they were also classified as scrub. This could be due to the similarity of the spectral values. In some places thick forest were cleared for forestry plantations. These were classified as scrub.

The land-use/land-cover map was prepared mainly to identify the scrub jungle area for conducting field surveys in and around two protected areas. The map prepared gives an idea of the distribution of heterogeneous scrub jungle habitat. It is likely that Jerdon's Courser prefers particular type of scrub jungle. Habitat measurement taken in the places where it has been detected can be modeled using multivariate statistical analysis and this information can be used for large scale mapping of the potentially suitable habitat of the Jerdon's Courser with multi-temporal satellite images.

5.5.4 Status of the Jerdon's Courser and its habitat

The main objective of my study was to know the geographical range of the Jerdon's Courser. It was established that the current distribution of this species is only in and around the eastern part of the Sri Lankamaleswara Wildlife Sanctuary although considerable amount of scrub jungle habitat is present outside the protected areas. Jerdon's Courser is categorized as Critically Endangered in the IUCN Red List (BirdLife International, 2001) since it is believed to have a single, small declining population. It is listed under Schedule I of the Indian Wildlife (Protection) Act 1972, and is considered as priority species under the National Wildlife Action Plan (2002-2016) of the Government of India (Government of India, 2002).

Very little information is available on the population size of the Jerdon's Courser (BirdLife International 2001). It is presumed to have an estimated number of 250 mature individuals in the wild (IUCN 2006). It would be difficult to assess the population status with the results obtained from tracking strip or tape-transect survey. However, based on the estimates of tracking and response rate, it can be established here that this species tend to occur presumably in very low density. The habitat within which it occurs has enormous pressure due to various anthropogenic activities. Mechanical clearing of the scrub jungle habitat was observed in many places near these two protected areas during the study period mainly for agriculture (Conservation issues in and around the study area are discussed in detail in Chapter 7). Even within the protected areas, several inappropriate management practices were noticed during the study period. For instance, constructing check dams, percolation pond, trenches and clearing of the scrub jungle for forestry

plantations have largely altered the original nature of the scrub jungle habitat. Several bird species are susceptible to habitat alteration particularly rare and restricted range birds (Simberloff, 1994 and Raman, 2001) and species, which occurs in low density in a small geographical range are more likely to go extinct than the common species (Johnson, 1998).

Rarity, endemism, restricted range and land use change are some of the traits used for priority setting for conserving the species along with severity of the threat it faces (Mace & Collar, 2002) and all these traits are applicable for the conservation of Jerdon's Courser. Cassidy *et al* (2001) emphasize the importance of species poorly represented in protected areas. Thus, protection status of species was also included as a trait in setting the priority for conservation. Although, an area covering 43,600 ha was declared as Sri Lankamaleswara Wildlife Sanctuary mainly for the Jerdon's Courser, only c. 15 % of its land area has the scrub jungle habitat. About 5 % of the scrub jungle habitat is present outside the Sanctuary. Even though the Jerdon's Courser has been recorded in three new places, these are all within 15 km of the original rediscovery site. One of these sites falls in Yerraballi Forest Block. Although, this site belongs to Andhra Pradesh Forest Department, it is not a part of the sanctuary and various development activities were noticed in this place. This forest block is the largest contiguous scrub present in the eastern part of the Sanctuary. The scrub extends well beyond the forest block from here. Similarly, a large part of the scrub jungle falls partially in Muthukuru Forest Block in Sri Penusula Narasimha Wildlife Sanctuary.

According to Islam & Rahmani (2004) 45% of the Important Bird Areas in India are present outside the protected area network. They have also emphasized the importance of legal protection of those areas either as sanctuaries or eco-sensitive areas. Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries are considered as Secondary Area where a single restricted range species is found (Stattersfield *et al*. 1998). Both the sites were designated as Important Bird Areas (Islam & Rahmani, 2004). Scharlemann *et al* (2004) predicted that by the year 2050 the proportion of area of Endemic Bird Areas used for agriculture is likely to increase from 1.06 to 1.34 fold depending on the four different scenarios developed by United Nations Environment Program (UNEP, 2002). Also Blamford & Long (1994) suggest that deforestation

rates are very high near or within the Endemic Bird Areas. Butchart *et al.*(2004) shows that Red List Indices have declined drastically for Indo-Malayan bird species owing to deforestation and especially these indices were deteriorated in the threat status of birds of shrub habitat.

Endemic birds with restricted geographical range and small population size are of great conservation concern since they are vulnerable to extinction (Wright & Hubbell, 1983). The principal cause of extinction of several species is essentially due to anthropogenic activities such as habitat destruction and degradation (Thomas, 1994 and Pimm *et al*, 1995). Gage *et al.*(2004) have shown that species that occurs in lower elevation tend to have a higher risk of extinction since they are expected to be more susceptible for human mediated disturbances.

It can be concluded here that since Jerdon's Courser has been categorized as critically endangered and its habitat is under great threat there is an urgent need to protect its habitat present outside the sanctuary areas and it is imperative to restore the habitat within the protected areas by following proper management based on scientific studies. Suitable alternative scrub jungle habitats should be identified through large-scale habitat mapping and survey should be conducted in the new areas to detect the presence of the Jerdon's Courser.

Chapter 6

Habitat requirement of the Jerdon's Courser

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6.1 Introduction

The Jerdon's Courser has been sighted mainly in the scrub jungle with open areas but information on its habitat preferences is not quantitative and is sparse (Bhushan 1990, BirdLife International 2001). The two other African congeners of the Jerdon's Courser, Three-banded Courser and Bronze-winged Courser, mainly prefer lightly wooded habitats and scrub (Maclean 1996). Habitat selection by birds is fundamental to understanding their biology and management (Cody 1985). Studying habitat selection would help ascertain important habitat features preferred by the target species for nesting, foraging, and roosting (Green *et al.* 2000, Lombardini *et al.* 2001). Determining the habitat requirements would be helpful in mapping potentially suitable habitat and focusing conservation efforts in high priority areas. It is imperative to know the distribution of the suitable habitat to conduct surveys and to conserve it, especially for a critically endangered species (BirdLife International 2001).

Habitat selection and distribution of birds may be related to the structure of vegetation (Cody 1985). To study the selection of habitat and to quantify the features of scrub jungle that correlate with the extent of its use by Jerdon's Courser, tracking strip method, which retains characteristic footprints of Jerdon's Courser was used. Habitat use of several carnivorous mammals (Emmons, 1987 and Mahon *et al* 1998), small mammals (Mukherjee, 2000 and Ottino, 2004) and rodents (Brown, 1988, Lagos *et al* 1995 and Abramsky *et al* 2002) was studied by using information gathered from the occurrence of footprints in relation to their habitat. As far as the birds are concerned habitat use was studied only for the Houbara bustard *Chlamydotis undulata macqueenii* by following their tracks (Launay *et al*, 1997).

6.2 Study area

I conducted study in and around the eastern part of Sri Lankamaleswara Wildlife Sanctuary, in the valley of the River Sagileru. Habitat selection of the Jerdon's Coursers was studied in areas of open scrub and trees in the alluvial wash below the eastern slopes of the Lankamalai hill range at altitudes of 150–300 msl. These areas were bounded to the west by the dense scrub and forests of the higher elevations of the hills and to the east by pastures, orchards

and croplands in the valley bottom. The scrub zone was traversed from west to east by streams that run in the monsoon season (May–October) and dry out during the rest of the year. Corridors of dense scrub and trees were found along the margins of these streams, with a mixture of open areas and scrub between. The substrate consisted of alluvial soil, gravel or stones. The ground vegetation was sparse and dominated by grasses, which dry up during the dry season. The area was used by people from villages in the Sagileru valley for grazing herds of domestic water buffalo, sheep and goats and for woodcutting. Wild large herbivorous mammals in the study sites were Chinkara *Gazella bennettii*, Chital *Axis axis* and Black-naped hare *Lepus nigricollis*.

6.3 Methods

6.3.1 Tracking strips

Tracking strip method, which retains characteristic footprints of Jerdon's Courser was used to study its habitat selection. Information collected from 11 tracking strip blocks, which consist of 157 tracking strips deployed in 2001 and 2002 was used for this study (Table 6.1, Map 6.1a &b). It should be noted that tracking strips were deployed either 50m or 100m regular square grid in all the blocks except for the block in the main Jerdon's Courser area (JC1 & JC2). Here it was placed at irregular spacing (24–72 m between nearest neighbours). Total strip nights monitored for 157 tracking strips was 5109. The number of nights of monitoring was calculated for each strip and averaged 32.5 nights per strip (range 3–79). Only six strips were monitored for less than 10 nights.

6.3.2 Recording habitat around the tracking strips

Within a 10-m square plot centred on each strip, all bushes and trees were assigned to 1-m height classes with the help of a calibrated stick, and identified to species level. Specimens were taken and compared with herbarium material to confirm their identity. Proportion of 12 most abundant tree and bush species were taken using the principal component analysis. The numbers of plants of *Dodonaea viscosa* and tussocks of the grass *Cymbopogon citrates* in the plot were also counted as the only other large plants present. Visual estimates to the nearest 5% were made of the proportion of the substrate within the square plot that was soil, gravel (mean stone diameter < 2 cm) and stones (mean stone

diameter > 2 cm) and the proportion of the square plot covered by grasses. Signs of woodcutting by humans, such as recently cut branches and trunks were also recorded.

6.4 Statistical analysis

6.4.1 Principal components analysis of bush species composition

Twelve most abundant tree and bush species were selected from all the plots combined. The number of individuals of each species in each plot was expressed as a proportion of the plot-total for those species. This proportion was arcsine square root transformed and Pearson correlation coefficients calculated for each pair of species (Table 6.2). Principal components analysis (PCA) with no rotation was performed on the matrix of correlations.

6.4.2 Tracking rate in relation to vegetation survey

The probability per night of monitoring that a tracking strip was crossed by a Jerdon's Courser was modelled by logistic regression as a function of variables measured around each strip. The programme, GLIM 4 was used to fit logistic regression models, with the number of Jerdon's Courser tracking events as the dependent variable and the number of nights for which the strip was monitored as the binomial denominator (Crawley 1993). The analysis assumed that each night of monitoring was an independent binomial trial, even for different nights at the same location. Model selection was by a step-up procedure, beginning with the effects of single variables and their squares. The square of an independent variable was included in the model along with the variable itself to allow for curvilinear quadratic relationships. At each step, the change in deviance from including each of the variables not already included in the model, together with its square, was calculated and the most significant of these was selected, provided that its effect was significant at $P < 0.05$. Interaction terms were not considered.

After including a new variable, the effects of all the variables already in the model, including squares, was tested by deleting each in turn and performing a likelihood-ratio test. Any term whose

Map 6.1a Distribution of the 11 tracking strip blocks deployed consist of 157 tracking strips in and around Sri Lankamaleswara Wildlife Sanctuary. Tracking strip blocks of main Jerdon's Courser area comes inside the box shown. Expanded view of this area can be seen in Map 6.1b.

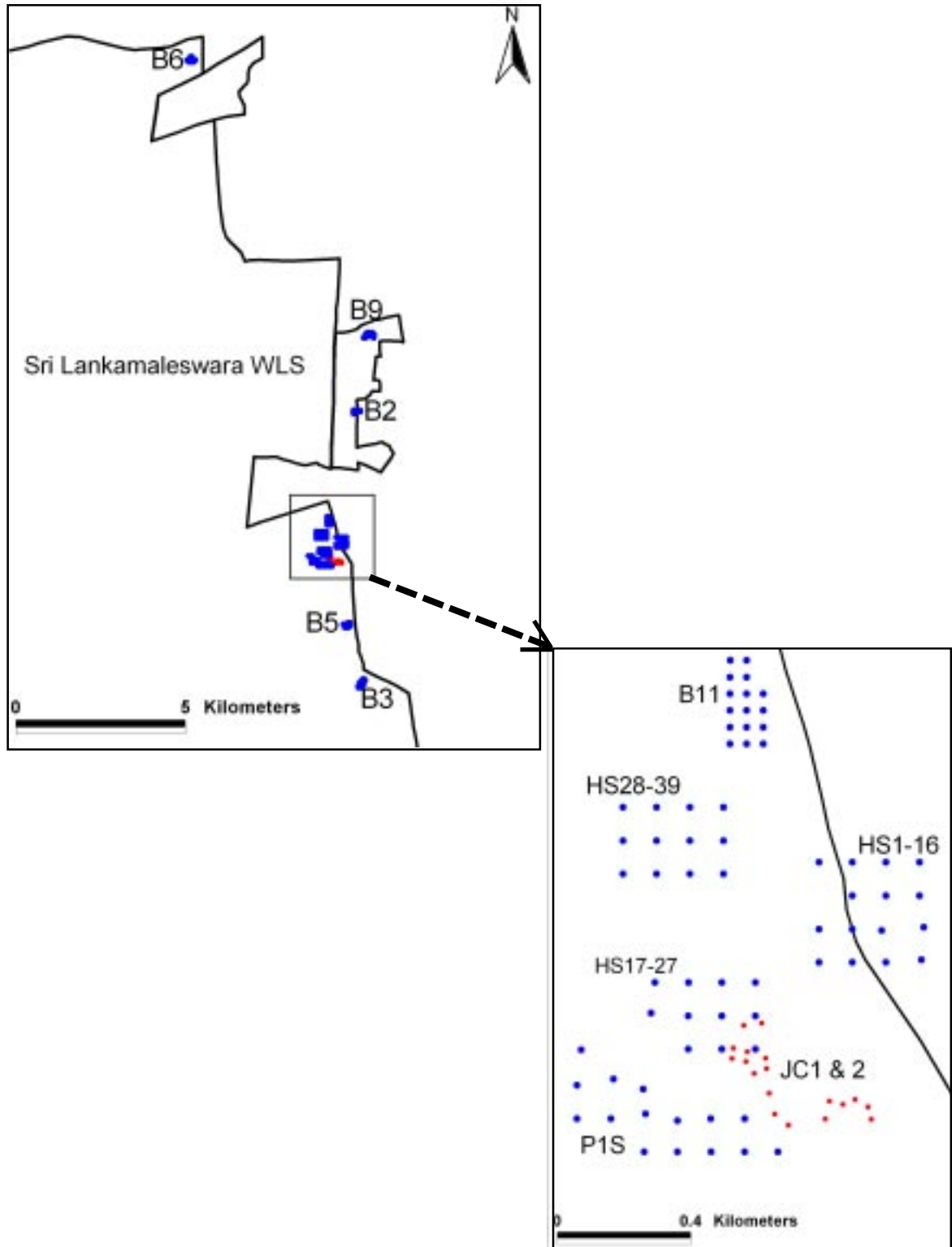


Table 6.1. Deployment of tracking strips and records of tracks of Jerdon's Courser in the 11 blocks shown in Map 6.1

Sl. No.	Year	Block	First strip deployed	Last check	No. of strips deployed	Strip nights	Jerdon's Courser tracking events	Strips with Jerdon's Courser tracks
1	2001	P1S	25-Apr-01	6-Jun-01	16	421	0	0
2	2001-2002	JC1&JC2	30-Jan-01	13-Jun-02	18	863	27	11
3	2001-2002	B2	6-Dec-01	21-Feb-02	12	477	0	0
4	2001-2002	B5	7-Dec-01	21-Feb-02	10	313	0	0
5	2001-2002	B3	8-Dec-01	20-Feb-02	16	477	3	2
6	2001-2002	B9	9-Dec-01	18-Feb-02	17	435	3	2
7	2002	B6	15-Feb-02	6-Mar-02	14	231	3	3
8	2002	B11	19-Feb-02	28-Mar-02	16	555	0	0
9	2002	HS 1-16	27-Feb-02	4-May-02	15	756	1	1
10	2002	HS 17-27	8-Apr-02	24-May-02	11	334	4	4
11	2002	HS 28-39	11-Apr-02	3-May-02	12	247	1	1
TOTAL					157	5109	42	24

effect was not significant at $P < 0.05$ was deleted. The procedure ended when no significant reduction in deviance resulted from the inclusion in the model of any further terms. This resulted in the selection of a minimal adequate model (MAM; Crawley 1993) in which the deletion of any variable or factor resulted in a significant increase in the deviance, and none of the variables and factors excluded from the model had a significant effect when included.

For all the MAM generated in these analyses, the residual deviance was less than the residual degrees of freedom, so no adjustment was made for overdispersion. This model selection procedure, as described above, did not take into account the spatial autocorrelation of tracking rates. There are chances that tracking rates of the Jerdon's Courser in the tracking strips which are close together to be more similar than those further apart. This could be because tracking events are measured from a small number of birds that have home ranges that overlap several tracking strips or because the habitat around the tracking strips close together might be more similar than strips further apart. The analysis done here assumes that there is no spatial link between the tracking rates from different tracking strips. If the spatial autocorrelation variable is significant, that means that tracking strips closer together are more similar. To check this, and therefore to make a more stringent test of effects of independent variables, the selected variables were screened in two ways.

First, to the initial MAM a factor BLOCK was added as a fixed effect to represent variation in tracking rate among the 11 survey blocks. Any variables that were not significant after the inclusion of BLOCK were deleted from the model one by one, beginning with the least significant, until all remaining variables were significant. Secondly, an autocovariance term *autocov* was calculated using the autologistic method of Augustin *et al* (1996). Their equation was adapted to give a value for *autocov* for the *i*th tracking strip as,

$$autocov_i = \sum_{j \neq i}^{j=N} (y_j / d_{ij}) / \sum_{j \neq i}^{j=N} (1 / d_{ij}), \quad \text{equ 1}$$

Table 6.2 Pearson correlation coefficients between arcsine square root transformed proportions of the 12 most abundant bush species in the 157 vegetation survey plots.

Species	Zr	Cc	Ah	Rd	Ta	Hb	Me	Cp	Ip	Df	Gr
<i>Zizyphus rugosa</i> (Zr)											
<i>Carissa carandas</i> (Cc)	-0.120										
<i>Acacia horrida</i> (Ah)	-0.341	0.131									
<i>Randia dumetorum</i> (Rd)	-0.077	-0.205	-0.047								
<i>Tarennia asiatica</i> (Ta)	-0.314	-0.225	-0.105	-0.007							
<i>Hardwickia binata</i> (Hb)	-0.309	-0.237	-0.169	0.008	-0.108						
<i>Maytenus emarginata</i> (Me)	-0.178	0.159	0.057	-0.224	0.169	-0.145					
<i>Canthium parviflorum</i> (Cp)	-0.377	-0.003	0.053	-0.003	0.133	-0.129	-0.042				
<i>Ixora pavetta</i> (Ip)	-0.215	-0.139	-0.153	-0.123	0.273	-0.091	0.232	0.047			
<i>Diospyros ferrea</i> (Df)	-0.374	-0.230	-0.188	-0.007	0.566	-0.007	0.180	0.149	0.294		
<i>Grewia rhamnifolia</i> (Gr)	0.169	-0.222	-0.087	0.306	-0.151	-0.056	-0.261	0.003	-0.180	-0.106	
<i>Pleiospermium alatum</i>	-0.245	-0.289	-0.102	-0.029	0.496	-0.085	-0.032	0.153	0.268	0.579	-0.062

where y_j is the tracking rate at the j^{th} strip and d_{ij} is the distance between the i^{th} and j^{th} strips. Summation was carried over all $N = 157$ strips except the i^{th} strip. Variables in the initial MAM that were no longer significant after the inclusion of *autocov* were deleted as in method 1.

6.4.3 Examining the performance of models

Receiver operating characteristic (ROC) analysis (Metz 1978) was used to examine the performance of MAM of tracking rates based upon vegetation data. ROC analysis avoids the use of an arbitrary choice of threshold for defining expected presences and absences (Manel *et al* 2001). Expected number of tracking events was calculated at each strip under a particular model and then used various threshold values of this score to generate a plot of sensitivity against (1-specificity) from each confusion matrix of observed and expected presences and absences. The area under the curve (AUC) was obtained from this plot. The numbers of nights of monitoring per strip were unequal and contributed to the calculation of expected values, so the usual assumption that $AUC = 0.5$ under the null hypothesis was not correct. Therefore AUC_{nul} was calculated under a null model that assumed that the tracking rate was the same for all strips, and calculated a performance score from the AUC for a particular model as:

$$(AUC - AUC_{\text{nul}}) / (1 - AUC_{\text{nul}}) \quad \text{eqn 2}$$

This score could vary between 0 for a model that performed no better than the null model, to 1 for a model that discriminated perfectly between tracked and untracked strips.

6. 5 Results

6.5.1 Occurrence of the Jerdon's Courser

Footprints of Jerdon's Coursers were recorded on a total of 24 tracking strips in seven of the 11 blocks (Table 6.1). The call of Jerdon's Courser was heard in blocks HS 1-16, HS 17-27, S 28-39, B9 and JC1 & JC2 in all of which tracks were also recorded.

6.5.2 Vegetation and ground cover of survey sites

The relative abundances of the 12 most common bush and tree species were shown in Figure 6.1. The dominant woody vegetation in the survey plots was shrubs, particularly *Zizyphus rugosa*, *Carissa carandas* and *Acacia horrida*. The first three components from the PCA of species composition accounted for 50% of the variation among plots (23%, 15% and 12%, respectively; eigenvalues 2.76, 1.80, 1.44). PC1 was positively associated with the relative abundance of *Tarennia asiatica*, *Diospyros ferrea* and *Pleiospermium alatum* and negatively associated with *Zizyphus rugosa*. PC2 was positively associated with the relative abundance of *Randia dumetorum* and *Grewia rhamnifolia* and negatively associated with *Carissa carandas* and *Maytenus emarginata*. PC3 was positively associated with the relative abundance of *Zizyphus rugosa* and negatively associated with *Acacia horrida* and *Canthium parviflorum* (Table 6.3).

Correlations among the relative abundances of these species are given in Table 6.2. Most bushes were < 2 m tall (Table 6.4) and *Hardwickia binata* was the only common species that often exceeded 4 m in height. Mean values of the principal components scores varied considerably among blocks. Evidence of cutting of trees and bushes by humans was visible in > 60% of survey plots in all blocks. Grasses covered about half of the ground surface. The main substrate types were stones (c.40%) and fine soil (c.60%).

6.5.3 Tracking rate in relation to vegetation and substrate

Logistic regression analysis was carried out in which the probability per strip night of a Jerdon's Courser tracking event was modelled in relation to all of the variables listed in Table 6.5. When data from all strips were included and spatial autocorrelation was not considered, the selected minimum adequate model (MAM) included a negative effect on tracking rate of the density of small bushes, a quadratic effect of the density of large bushes, with an optimum at 5.59 bushes 10-m square plot (559 bushes ha⁻¹) and a negative effect of PC3 score (Table 6.5). Strips tracked by Jerdon's Coursers tended to have low densities of small and large bushes and PC3 scores below the overall median (Figure 6.2). There was a unimodal relationship between tracking

rate and the density of large bushes (Figure 6.3). Comparison of mean percentage composition of common bush species in plots where the strip was or was not tracked by Jerdon's Courser indicated a lower relative abundance of *Zizyphus rugosa* at tracked than untracked sites and higher abundances of *Acacia horrida*, *Randia dumetorum* and *Hardwickia binata* (Figure 6.1). These differences were in accord with the correlations of these species with the PC3 score (Table 6.3) and the negative effect of the PC3 score on tracking rate.

When the four blocks in which Jerdon's Courser tracks were not found were excluded from the analysis, the MAM included the same variables and the model parameter estimates were similar (Table 6. 5). There was significant variation in tracking rate among blocks when the factor BLOCK was added to the MAM selected for data from all blocks. The effect of the spatial autocorrelation variable *autocov* was also highly significant. When BLOCK or *autocov* were included in the model, the effect of PC3 score became non-significant. When BLOCK was included in the model, the effect of the density of small bushes became non-significant, but it remained significant when *autocov* was included. The quadratic effect of large bush density remained significant in this model and the optimum bush density also remained similar.

6.6 Discussion

6.6.1 Receiver operating characteristic (ROC) analysis

The performance of the MAM derived from the ground-based vegetation data was examined by discriminating sites where Jerdon's Courser tracks were recorded from those where they were not by using ROC analysis. The performance measure is derived from the area under the curve (AUC) of Receiver Operating Characteristic plot. As a result the logistic regression analysis of Jerdon's Courser tracking rates on ground-based vegetation survey data yielded statistical models that included highly significant effects (Table 6.6).

6.6.2 Habitat preferences of the Jerdon's Courser

The most robust finding was that Jerdon's Coursers were most likely to occur in areas of scrub jungle with intermediate densities of large bushes. All the MAM based upon vegetation survey data supported this conclusion. Densities of about 300–700 large (> 2 m tall) bushes ha⁻¹

Figure 6.1. Mean percentage composition of trees and bushes in 10-m square vegetation survey plots which contained tracking strips from which tracks of Jerdon's Courser were (filled bars) or were not (open bars) recorded. Species are presented from left to right in order of descending overall abundance.

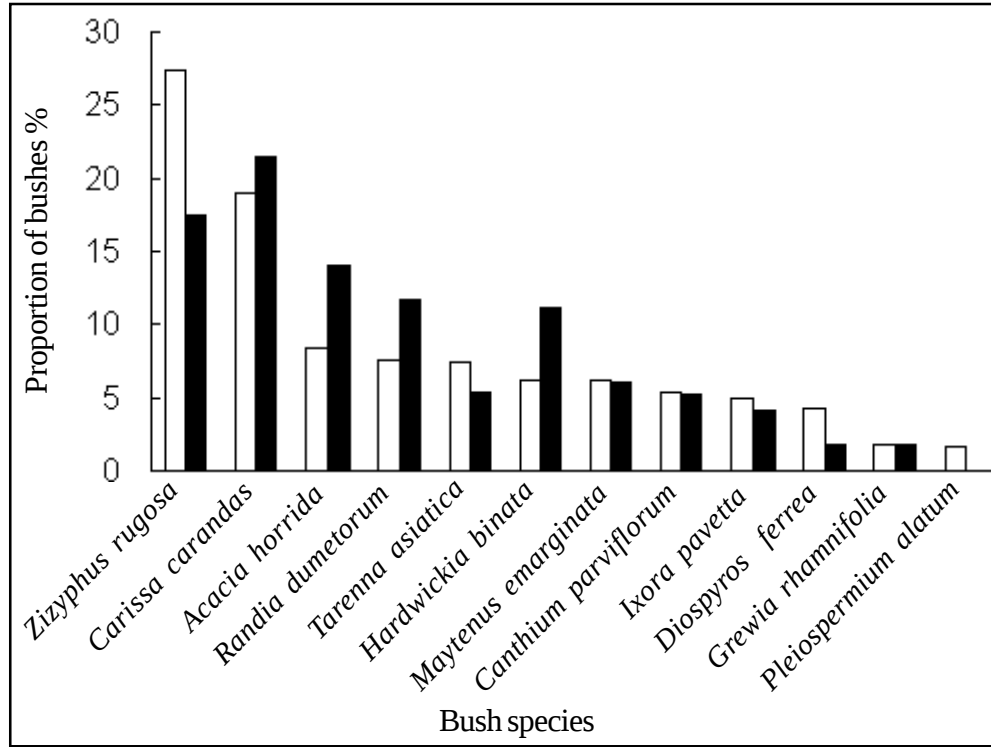


Table 6.3 Correlations of species abundances with the first three principal components from an analysis of the proportions of the twelve most abundant tree and bush species in the study areas. Proportions were arcsine square root transformed before analysis.

Species	PC1	PC2	PC3
<i>Zizyphus rugosa</i>	-0.561	0.269	0.672
<i>Carissa carandas</i>	-0.268	-0.687	-0.061
<i>Acacia horrida</i>	-0.100	-0.445	-0.563
<i>Randia dumetorum</i>	-0.082	0.532	-0.377
<i>Tarenna asiatica</i>	0.771	0.085	0.077
<i>Hardwickia binata</i>	-0.009	0.228	-0.242
<i>Maytenus emarginata</i>	0.289	-0.561	0.266
<i>Canthium parviflorum</i>	0.317	-0.072	-0.507
<i>Ixora pavetta</i>	0.547	-0.103	0.311
<i>Diospyros ferrea.</i>	0.819	0.147	0.057
<i>Grewia rhamnifolia</i>	-0.269	0.595	-0.167
<i>Pleiospermium alatum</i>	0.732	0.250	0.047

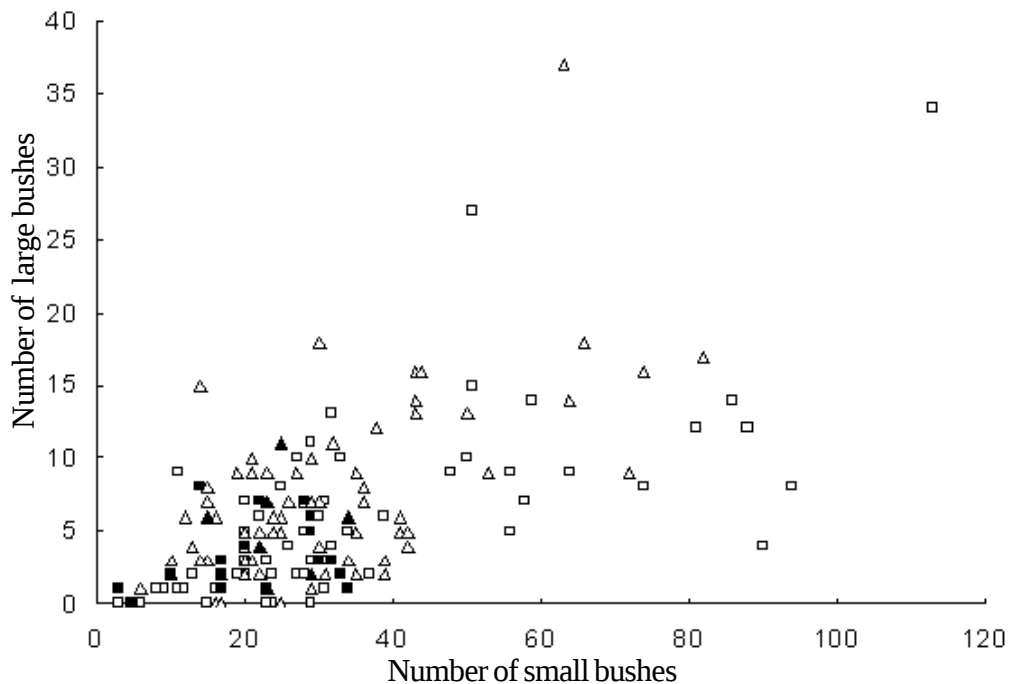
Table 6.4. Means and standard errors (italics) in survey blocks for counts of bushes, *Cymbopogon* sp. grass tussocks, and *Dodonaea viscosa* plants, percentage cover of substrate types and other grasses, proportion of plots in which there was evidence of wood cutting (Cut) and the first three principal components from an analysis of the species composition of trees and bushes. Means for all plots containing strips with and without Jerdon's Courser (JC) records are also shown. Sample sizes are given in Table 6.1.

Block	Small bush	Large bush	Cymbopogon	Dodonaea	Stones	Gravel	Soil	Grass	Cut	PC1	PC2	PC3
P1S	21.3	2.2	3.4	0.6	0	0	69	63	5	0.10	0.20	-0.48
JC1 & JC2	19.0	3.0	3.4	0.9	0	6	81	64	4	-0.18	0.14	-1.01
B2	20.8	3.6	4.9	1.2	0	8	71	69	7	0.28	0.21	-0.60
B5	20.8	2.7	6.4	1.4	0.1	1.2	61	72	5	-0.70	0.16	-0.05
B3	48.0	6.3	8.2	1.1	16.4	2.5	0.4	31	64	6	1.71	0.13
B9	24.6	2.7	4.5	0.8	0	0	6.0	95	9	-0.32	0.13	-0.86
B6	25.4	2.3	4.1	0.9	0	0	1.4	80	5	-0.40	0.17	1.08
B11	47.6	4.6	10.8	1.6	0	0	2.4	19	6	1.52	0.28	0.05
HS1-16	36.3	3.2	8.8	2.3	0	0	16.1	30	10	0.37	0.24	-0.18
HS17-27	33.7	7.9	4.8	1.4	0	0	13.8	2.7	33	0.45	0.20	-0.25
HS-28-29	39.8	8.3	10.4	2.6	0	0	10.1	1.8	46	0.20	0.34	-0.10
No JC	32.6	1.8	6.7	0.5	1.6	0.5	7.9	0.7	42	0.04	0.09	0.10
JC	21.7	1.9	3.9	0.6	2.0	1.4	9.1	1.4	34	-0.22	0.15	-0.56

Table 6.5 Minimal adequate logistic regression models relating the logit of the probability of a Jerdon's Courser tracking event occurring per strip-night of monitoring to vegetation and substrate variables measured in a 10-m square plot centred on the strip. Variables listed in Table 6.2 that do not appear in this table did not have a significant effect at $P < 0.05$. Significance levels from likelihood-ratio tests for deletion of variables from the final model are shown by asterisks; * = $P < 0.05$; ** = $P < 0.01$; *** $P < 0.001$. The significance level given for the main effect of large bushes is that for the main effect and quadratic term combined. The significance levels for the constant term in the two right hand columns refer to the effects of block as a factor and the spatial autocorrelation term respectively.

Model specification & variables	Parameter estimates			
Blocks without JC excluded?	NO	YES	NO	NO
Block effect included in model?	NO	NO	YES	NO
Autologistic effect included in model?	NO	NO	NO	YES
Constant	-5.346	-4.843	***	***
Small bushes	-0.03947**	-0.04611***	n.s.	-0.03256*
Large bushes	+0.7060***	+0.7897***	+0.6908***	+0.5493**
(Large bushes) ²	-0.06138***	-0.07062***	-0.06772***	-0.04966**
PC3	-.5791***	-0.4883**	n.s.	n.s.
Residual deviance	109.47	72.81	60.84	86.63
Residual d.f.	152	103	144	152

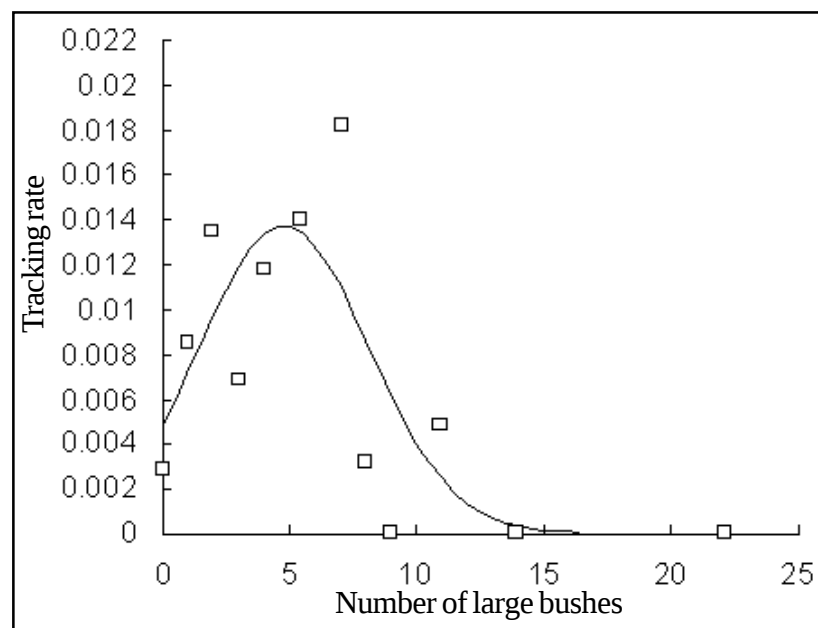
Figure 6.2. Numbers of large (>2 m high) and small (<2 m) bushes in 10-m square vegetation survey plots centred on 157 tracking strips. Each point represents a plot. Filled symbols denote plots which contained strips from which tracks of Jerdon's Courser were recorded and open symbols strips where they were not recorded. Squares represent plots with scores of the third principal component of vegetation composition (PC3) below the median and triangles represent plots with PC3 scores at or above the median.



and less than 1000 small (< 2 m) bushes ha⁻¹ are likely to be favourable to Jerdon's Coursers. Less quantitative descriptions of Jerdon's Courser habitat (summarized in BirdLife International 2001) are in accord with this finding. Descriptions of the habitat preferences of the two African congeners of Jerdon's Courser, *Rhinoptilus cinctus* and, particularly, *Rhinoptilus chalcopterus*, also emphasize the importance of lightly wooded habitats and scrub (Maclean 1996). This genus is unusual among nocturnal, visually foraging, charadriiform birds in using wooded areas where average light levels are likely to be low at night because of the shading effect of the canopy (Martin 1990). However, these results suggest that Coursers may still be able to see invertebrate prey on the ground by selecting relatively well-illuminated open areas.

These results suggest that land use by humans and grazing and browsing by wild and particularly domestic large herbivores have important effects on the suitability of habitat for Jerdon's Courser. The effects of domestic livestock on vegetation far outweigh those of wild gazelles and deer, as evidenced by the frequency of tracks on tracking strips. Mechanical clearing

Figure 6.3. Number of Jerdon's Courser tracking events per strip-night in relation to the number of large (>2 m high) bushes in a 10-m square plot centred on the tracking strip. Plotted points are for groups of bush number categories, which were grouped so that no bin contained data for less than 300 strip-nights. The curve is from the Minimum adequate model.



of bushes to create pasture, orchards or tilled land, high levels of woodcutting and too high a level of use by domestic livestock are likely to create habitats with too few bushes for Jerdon's Coursers. However, a low level of grazing and browsing by livestock or an absence of woodcutting might well lead to numbers of bushes that are too high.

Tracking strips were crossed frequently by domestic water buffalo, sheep and goats, and evidence of woodcutting was apparent in all of our survey blocks, so the level of use of the Sanctuary and adjacent areas by humans is clearly a relevant issue for conservation managers. Quantitative monitoring, together with a study of the social and economic factors that affect land use, would assist the management of the scrub jungle habitat in and around the sanctuary.

6.6.3 Value of tracking data for the study of habitat selection

The monitoring of tracking strips has several advantages as a method for studying habitat selection by the secretive and nocturnally active Jerdon's Courser. Visual records of Jerdon's Courser are difficult to obtain and require time-consuming searches by night. Conclusions about habitat selection from night searches are likely to be biased because the ease with which birds are detected is probably greatest in areas with few bushes and sparse ground vegetation. Tracking has the potential disadvantage that the tracks of other bird species, most probably Yellow-wattled lapwing and Chestnut-bellied sandgrouse, might be mistaken for those of Jerdon's Courser. However, confusion with lapwing footprints is unlikely in this study because the overlap in footprint

Table 6. 6. Performance of minimal adequate logistic regression models of tracking rate in relation to vegetation survey data, in discriminating 24 strips tracked by Jerdon's Courser from 133 that were not tracked. The performance measure is derived from the area under the curve (AUC) of Receiver Operating Characteristic plot. In each case, the performance of models fitted with and without excluding the blocks in which Jerdon's Courser (JC) tracks were not recorded is evaluated on the whole dataset.

Data used for model	Blocks without JC excluded?	Spatial autocorrelation (SA) term/block effect	Number of fitted parameters in the model	$(AUC - AUC_{nul}) / (1 - AUC_{nul})$
Vegetation survey	No	No	5	0.324
Vegetation survey	Yes	No	5	0.317
Vegetation survey	No	Yes (block)	3	0.151
Vegetation survey	No	Yes (SA)	4	0.167

characteristics between the two species is small (see Chapter 3) and Yellow-wattled lapwings are rarely seen in the types of habitat included in this survey. None was seen in the study blocks, even though lapwings are diurnal and easy to see in their preferred, more open habitats. Chestnut-bellied sandgrouse were often seen in the study areas, but close examination of footprints of this species allows accurate identification. Diagnostic characters include the size of pad at the junction of the toes (larger in sandgrouse), a different position of the junction of toes with the pad and distinctive drag marks from the claw of the central toe of the sandgrouse.

6.6.4 Use of satellite imagery to identify priority areas for Jerdon's Courser surveys

Information on the habitat requirements of the Jerdon's Courser would be of great help to underpin conservation measures. Knowledge of the Jerdon's Coursers distribution is incomplete and there is considerable pressure from human use of apparently suitable habitats. Hence, distribution mapping is a high conservation priority. Information on the habitat preference of the Jerdon's Courser described in this study can be useful to map potentially suitable habitat over large areas from satellite imagery and facilitate the design of surveys of Jerdon's Courser distribution. The use of models that relate the distribution or abundance of an animal to environmental variables is a potentially valuable approach to mapping the probable distribution of species that are difficult to survey (Fielding & Bell 1997). Estimating the bush density through ground surveys can be used to calibrate satellite image to produce habitat suitability map. These maps could then be used to select priority areas for Jerdon's Courser surveys. The use of tracking strips to study habitat selection and distribution has potential in studies of other scarce and secretive species.

Chapter 7

Conservation issues and recommendations

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7.1 Introduction

A total of 182 bird species around the world are classified as Critically Endangered and it was estimated that they have only 50% chance of surviving over the next 10 years or three generations (BirdLife International 2000). Ricketts *et al.* (2005) points out that globally there are 595 sites, harboring 794 faunal species, which includes the Jerdon's Courser, are threatened with imminent extinction. They also suggest that conserving these 595 sites should be an urgent global priority. One of the principal actions carried out for conserving of the critically endangered species around the world was habitat protection and management (Bell & Merton, 2002 and Butchart *et al.* 2006). Butchart *et al.* (2006) assessed that proper conservation actions implemented around the world during 1994-2004 prevented 16 bird species from extinction and the main threats for these species were habitat loss and degradation. Human induced threats such as habitat destruction and degradation as well as high and increasing human population density are the primary causes of endangerment and extinction of many species globally (Kerr & Currie 1995, Pimm *et al.* 1995).

Exploitation of scrub jungle habitat, livestock grazing, and quarrying are the major threat identified so far for the Jerdon's Courser (Birdlife International 2001). Bhushan (1990) stated that major threat for the Jerdon's Courser and its habitat was the collection of minor forest produce such as fuel wood and timber by the local villagers in and around the Sri Lankamaleswara Wildlife Sanctuary. Soon after the construction of the Somasila dam, 57 villages were displaced and relocated near the Sri Lankamaleswara Wildlife Sanctuary and this poses a serious threat to the scrub jungle habitat (Bhushan 1995). Although the issues and threats for the scrub jungle habitat near the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries were identified, there is no quantitative information available and there is no proper management plan present exclusively for the Jerdon's Courser habitat. There is an urgent need to comprehensively study the long-term impacts of such habitat changes and landscape alteration on the Jerdon's Courser and identify ameliorative conservation measures.

7.2 Study area and Methods

Disturbances for the scrub jungle habitat and other anthropogenic activities such as amount of livestock grazing were documented near the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries from the year 2000 to 2005. Scrub jungle with open areas, which are potentially suitable habitat of the Jerdon's Courser have been cleared and developmental activities have taken place in and around the sanctuary areas during the study period. Telugu-Ganga Canal was constructed in and around the Sanctuary areas during October 2005. All these anthropogenic activities were recorded and the places where such activities occurred were marked using GPS. Potentially suitable habitat of the Jerdon's Courser was mapped with the help of satellite imagery (Discussed in Chapter 5). Extent of the area cleared was mapped by walking along the edge with GPS. Map of the cleared areas was kept as an overlay on the scrub jungle habitat map to find out the extent of the loss of suitable habitat of the Jerdon's Courser. This was achieved with the help of ERDAS imagine 8.5 and Arc View GIS 3.2a software.

Instances of livestock grazing were established by looking at the footprint of goats, sheep and buffalo and the rate of tracking was calculated. Number of households and cattle population was collected by interviewing locals from the 14 villages around the northern and eastern boundary of the Sri Lankamaleswara Wildlife Sanctuary. This was done with the help of volunteers and Andhra Pradesh Forest Department staff in November 2005.

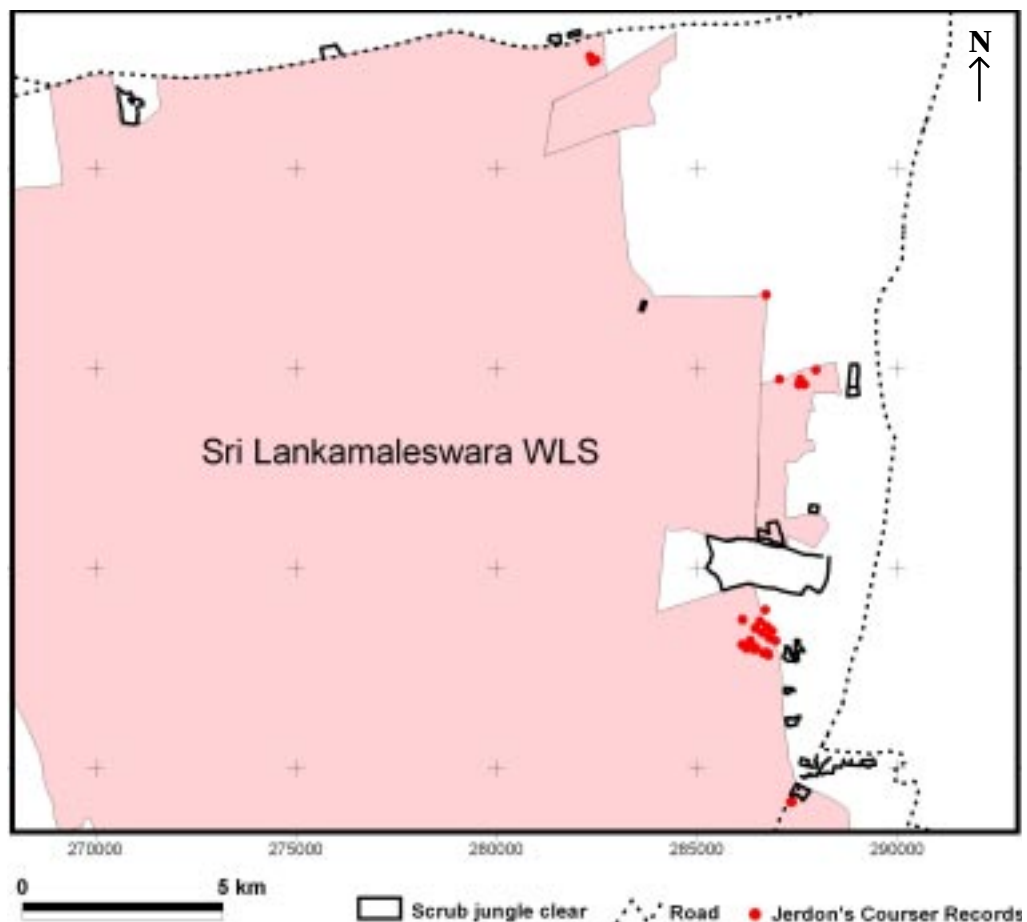
Amount of woodcut was quantified by noting the scrub and tree species cut in the 10 m square habitat recording plots. Totally 294 plots were surveyed in and around the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries as well as in the reserve forest areas of Velikonda foothills. Apart from this, amount of human use of these forest areas was quantified by calculating the rate of encountering the head load, cartload and tractor load of timber and Non Timber Forest Produces (NTFP).

7.3 Results

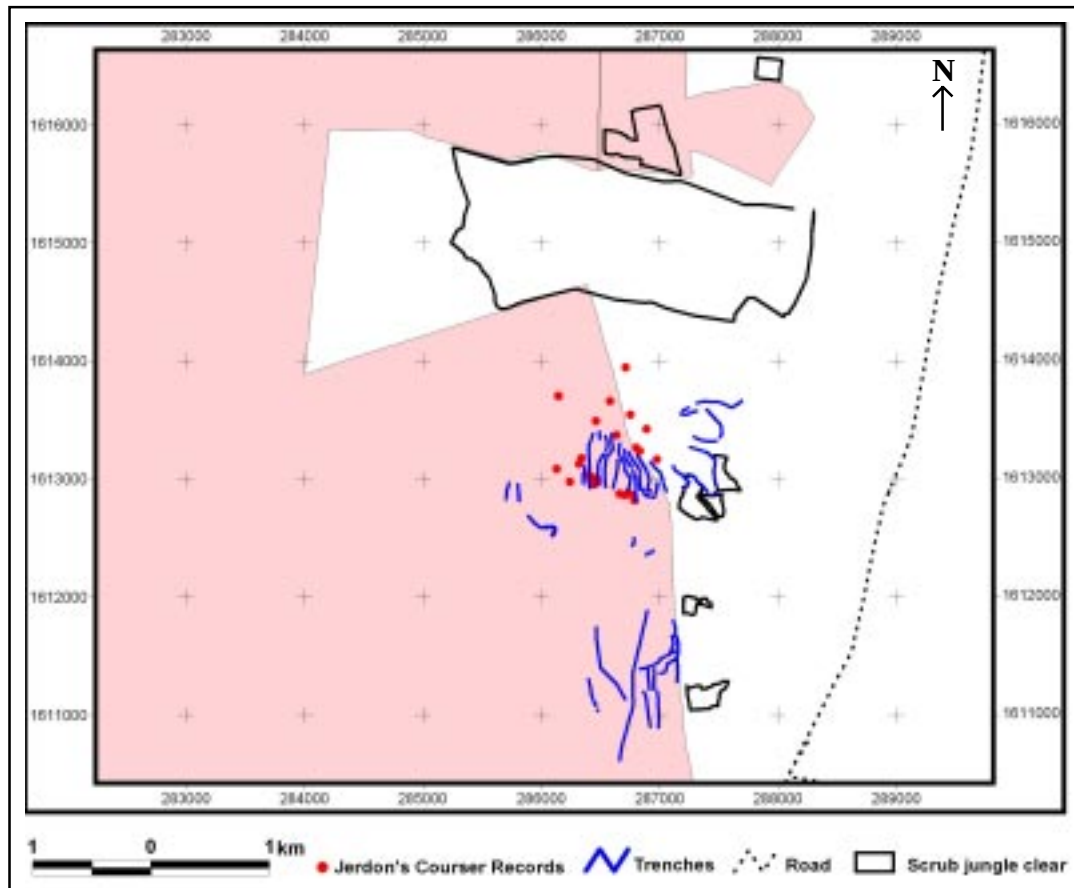
7.3.1 Scrub jungle clearance for farming and plantation

A large area of about 480 ha of the scrub jungle was cleared during the study period (2001-04) in and around the Sri Lankamaleswara Wildlife Sanctuary. Of this, nearly 275 ha of the scrub jungle, which is potentially suitable for the Jerdon's Courser, had been cleared to provide land for agriculture to the people who were displaced by floods, and also for lemon farming and forestry plantations. These cleared places fall within about 1 km from the previously known as well as newly detected Jerdon's Courser areas (Map 7.1). Scrub jungle habitat was cleared inside the Sri Lankamaleswara Wildlife Sanctuary mainly for raising forestry plantation consists of exotic tree species such as *Pongamia pinnata*, *Terminalia arjuna*, *Cassia siamea*, *Eucalyptus sp.* and *Syzygium cumini*.

Map. 7.1 shows the scrub jungle clear and the Jerdon's Courser records in and around the Sri Lankamaleswara Wildlife Sanctuary.



Map. 7.2 shows the trenches and scrub jungle clear in and around the main Jerdon's Courser area in the Sri Lankamaleswara Wildlife Sanctuary.



7.3.2 Developmental activities inside the Sri Lankamaleswara Wildlife Sanctuary

Apart from the plantations several other developmental activities such as construction of check dams, percolation ponds, digging trenches were noticed during the study period. It should be noted that trenches were dug in the places where the Jerdon's Courser has been seen regularly since its rediscovery in 1986. The trenches stretch in different lengths from about 50m to 1.3 km long, 2 m deep and the width varies from 2 to 5 meters (Map 7.2). The trenches were dug at the intervals of 20 to 50 m. Trees and shrubs, which are on the path of the trench line, were uprooted and thrown aside. Stones and the soil was dug up and piled next all along the trench.

Five percolation ponds were constructed near the main Jerdon's Courser area during the study period. About 0.5 to 1 ha of scrub jungle was cleared for each ponds and the earthen bund was constructed by piling up the soil dug for the pond. In the bund, exotic plants species were

planted. Apart from this in the scrub jungle habitat another type of forestry practice called thinning and singling in which all the scrub species were cleared except the saplings (1-2 m in height) of tree species such as *Hardwickia binata*, *Anogeissus latifolia*, *Manilkara hexandra* and *Soymida febrifuga*. Later circular pits were dug around these trees, which facilitates collection of rainwater. Also several small pits were dug for rainwater collection in the cleared open areas where this thinning was carried out.

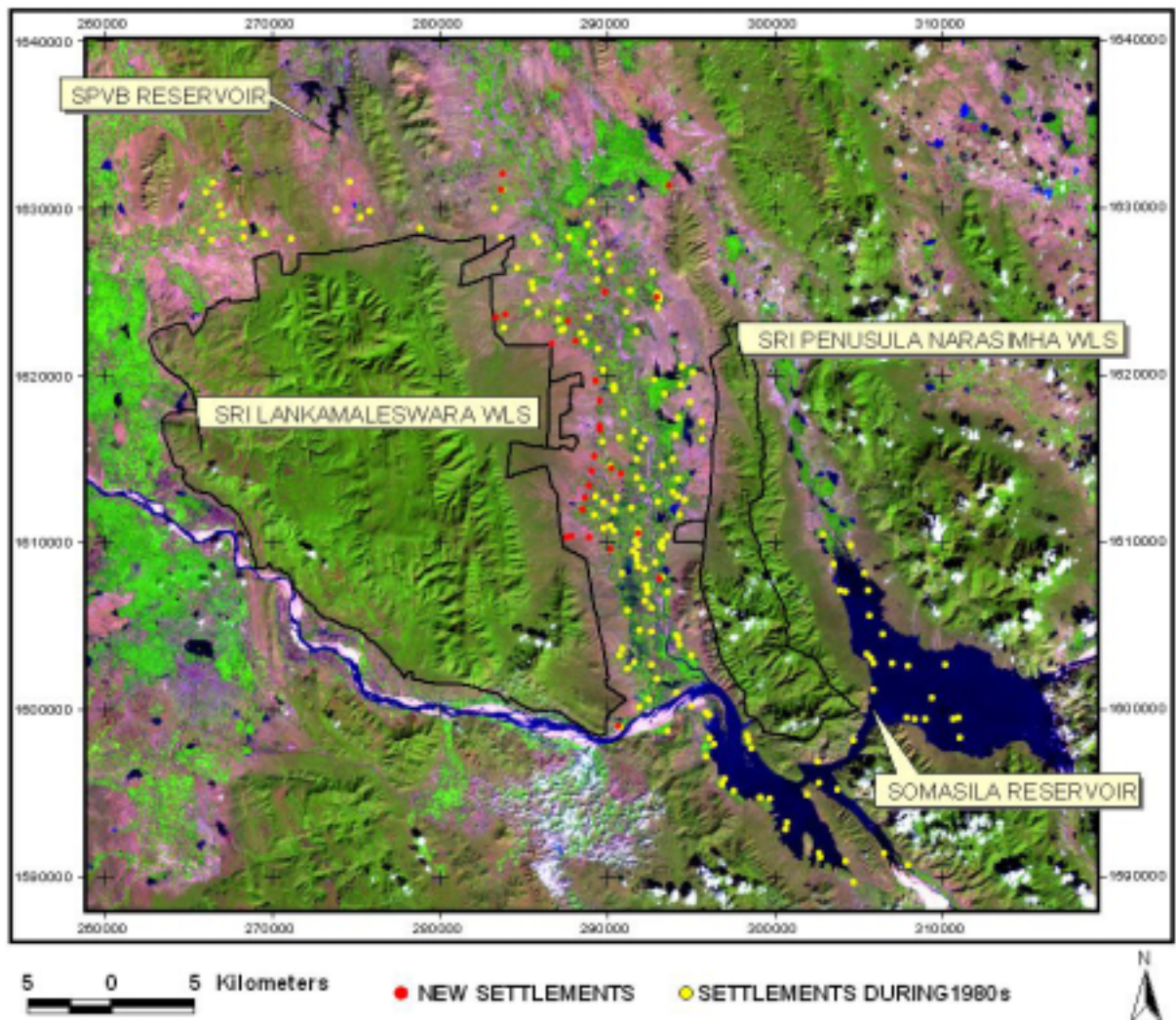
7.3.3 Quarrying in and around the Sri Lankamaleswara Wildlife Sanctuary

Stones of different sizes (average stone diameter is 10 to 30 cm) present on the ground were collected for road construction every year from the scrub jungle habitat both in and outside the Sri Lankamaleswara Wildlife Sanctuary. Apart from this bigger stones buried inside the ground were dug up by crowbars and broken into pieces and collected in heavy vehicles. These stones were collected for house construction by the nearby villagers. Large pits were dug up in about 15 places in and out side the eastern part of the Sri Lankamaleswara Wildlife Sanctuary. However, no instance of using explosives for quarrying was reported during the study period.

7.3.4 Increasing number of settlements near the sanctuary area

Bhushan (1995) reports that construction of Somasila dam resulted in displacement of 57 villages near the Sri Lankamaleswara Wildlife Sanctuary. The construction of Somasila dam was completed in the year 1989 (Nikku, 2004). Locations of the villages near the study area were taken from the Survey of India toposheets, which was surveyed in 1986 prior to the construction of Somasila dam. GPS locations were taken from recent villages near the Sri Lankamaleswara Wildlife Sanctuary. These locations were plotted and the map was produced. Village locations taken from the toposheets plotted on the Landsat ETM Satellite image of 6th December 2000 shows that nearly 45 villages were submerged under the Somasila reservoir (Map 7.3). There are about 146 villages present in between the eastern part of the Sri Lankamaleswara Wildlife Sanctuary and the western side of the Cuddapah division of the Sri Peninsula Narasimha Wildlife Sanctuary. Of these 146 villages, 25 were formed in recent times (within 10 to 15 years). This was established by

Map. 7.3 Settlements near the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries. Yellow dots indicates old settlements (during 1980's) are taken from Survey of India toposheets and red dots are new settlements (formed within 10-15 years) mapped during this study. Note that settlements submerged inside the Somasila and Sri Potuluru Veera Brahmendraswamy (SPVB) reservoirs were displaced mainly near the sanctuary areas.



interviewing the local people from these villages. It should be noted that most of these villagers moved from the bank of the Sagileru River, which runs in between Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries. It was observed during the study period (from 2000 to 2005) that Sagileru river was flooded three times during the rainy season. Villagers near the bank of the Sagileru River moved towards west, near the Badvel- Siddavatam road, which is about 2 km away from the eastern boundary of the Sri Lankamaleswara Wildlife Sanctuary.

Besides this, about 15 villages were displaced due to the construction of Sri Potuluri Veera Brahmendraswamy (SPVB) Reservoir in the place called Bramhamgarimatam, which is about 12 km north of the Sri Lankamaleswara Wildlife Sanctuary (Map 7.3). Twelve villages present within 1 km from the northern boundary of the Sri Lankamaleswara Wildlife Sanctuary of which seven villages were resettled due to the construction of the SPVB reservoir near the Badvel-Mydukur Road, which partly forms the northern boundary of this sanctuary.

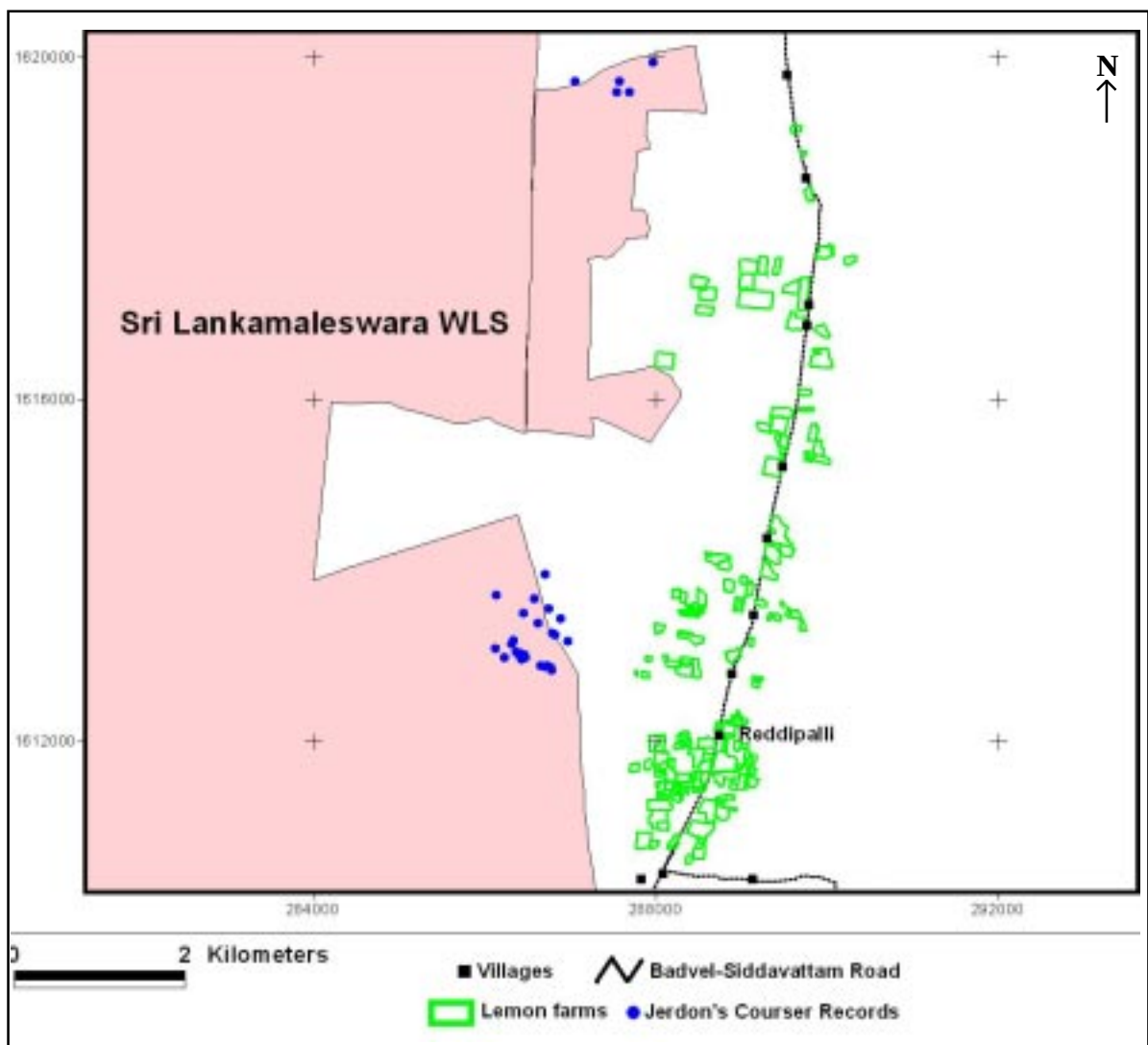
It should be noted that there are still few more villages in the submersible area of the Somasila and SPVB reservoirs, which are likely to be resettled near the Sanctuary area. Also there are plans to increase the height of the Somasila Dam, which would result in displacement of more villages from the southeastern part of the Sri Lankamaleswara Wildlife Sanctuary.

7.3.5 Lemon farms

Major crops around the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife sanctuaries are paddy *Oryza sativa*, sunflower *Helianthus annuus*, cotton *Gossypium* sp. Groundnut *Arachis hypogaea*, Finger millet *Eleusine coracana*, Turmeric *Curcuma longa* and Onion *Allium cepa*. However, in recent times, several agricultural fields have been transformed into lemon farms. Species such as Lemon *Citrus limon*, Bitter lime *Citrus aurantium*, Sweet lime *Citrus sinensis* and Key lime *Citrus aurantifolia* were grown since they needs relatively less water, low maintenance and are lucrative. This agricultural transformation, from growing dry irrigated crops to lemon farms, was mainly due to erratic and failure of seasonal rains. Lemon farms present near the eastern part of the Sri Lankamaleswara Wildlife Sanctuary were mapped in June

2004. Farms were extended for about 1.5 km either side of the Badvel-Siddavattam road. Extent of the lemon farms in this region consists of 198 ha (Map 7.4). This lemon farm map was kept as overlay on the land use land cover map of the December 2000 to find out the extent of scrub jungle transformed into lemon farms. Within three and a half years about 15 ha of scrub jungle habitat was transformed into lemon farms. It should be noted that about 215 ha of scrub jungle habitat was cleared out side the Sanctuary from 2000 to 2005 (Map 7.1). The land was provided by the Government of Andhra Pradesh for agriculture purpose to the people who were displaced by floods. Most of these lands were not yet cultivated and are most likely to be converted into lemon farms in future.

Map. 7.4 shows the distribution of the Lemon farms near the eastern part of the Sri Lankamaleswara Wildlife Sanctuary.



7.3.6 Livestock grazing

Three types of livestock grazing were observed in and around the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries. In the first type, shepherds brought their goats, sheep and buffalo regularly every morning from the villages into the scrub jungle habitat in and around the sanctuary areas. They stray inside the forest for about 2-3 km and return to their villages in the evening. Another type of graziers who are nomads possess 200 to 300 cattle. They rear only cows. However these are not for milk but mainly for the cow dung. They were generally invited by the lemon farm owners to enrich their farms. The grazers stay up to 3 to 4 months in one place before moving to another. All these cattle were seen grazing in the forested areas in and around the sanctuaries. The third type of graziers, are, who stays with their sheep inside the sanctuary for grazing for most of the year except during the rainy season. However, this type of grazing was not observed in the scrub jungle habitat.

Tracking strips (totally 410) were deployed in and around Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries as well as in the reserve forest areas of Velikonda foothills in 24 blocks, for detection of Jerdon's Courser (See Chapter 5). While recording the bird footprints in the tracking strips, tracks of goats, sheep and buffalo were also recorded. Footprints of human beings observed in the tracking strips were also recorded. Tracking rate of the cattle and human beings are relatively higher than the wild ungulates present in the study area. Goats and sheep tracked were found on 78.5 % of tracking strips. Buffalo and human tracks were recorded in 47% and 72 % of tracking strips respectively. Details of tracking events of cattle and human in 24 blocks of tracking strips were given in Table 7.1.

Data on cattle population and number of households were collected in November 2005 from 14 villages situated in the eastern (10 villages) and northern part (4 villages) of the Sri Lankamaleswara Wildlife Sanctuary. Goats and sheep populations were relatively high (38 and 36 % of the total population respectively) than the buffalo (23%). Total number of households recorded in these villages was 1,684. Maximum number of households was recorded in Reddipalli (300 households), which is near to the main Jerdon's Courser area. Cattle population exceeds

Table 7.1. Tracking rates of Goats & Sheep, Buffalo and Human in 24 blocks of tracking strips deployed in and around Sri Lankamaleswara and Sri Penusula Narasimha* wildlife sanctuaries and in the reserve forest areas of Velikonda foothills # from 2000 to 2003.

BLOCK	Tracking strip nights	Tracking rates		
		Goats & Sheep	Buffalo	Human
JC1&2	863	0.023	0.001	0.043
P1S	421	0.007	0	0.014
B1	112	0.071	0.009	0.009
B2	238	0.151	0	0.059
B5	458	0.076	0.114	0.020
B3	477	0.042	0.075	0.034
B9	435	0.092	0.177	0.053
B6	231	0.074	0	0.022
B11	555	0.072	0.020	0.016
HS1-16	756	0.050	0.009	0.029
HS17-27	684	0.029	0	0.035
HS28-39	247	0.016	0	0.053
B8	499	0.150	0.130	0.074
B4*	459	0.083	0.087	0.061
B7	460	0.167	0.209	0.061
B13 [#]	462	0.115	0.149	0.082
B14 [#]	454	0.097	0.099	0.066
B10*	387	0.090	0.111	0.041
B12 [#]	484	0.025	0.010	0.039
B15	471	0.110	0	0.021
B18	465	0.110	0.015	0.009
B17	512	0.068	0	0.012
B19	238	0.151	0	0.059
B20	207	0.053	0.068	0.058

Map 7.5 shows the number of households and cattle population in 14 villages situated within 2 km from the eastern and northern boundary of the Sri Lankamaleswara Wildlife Sanctuary.

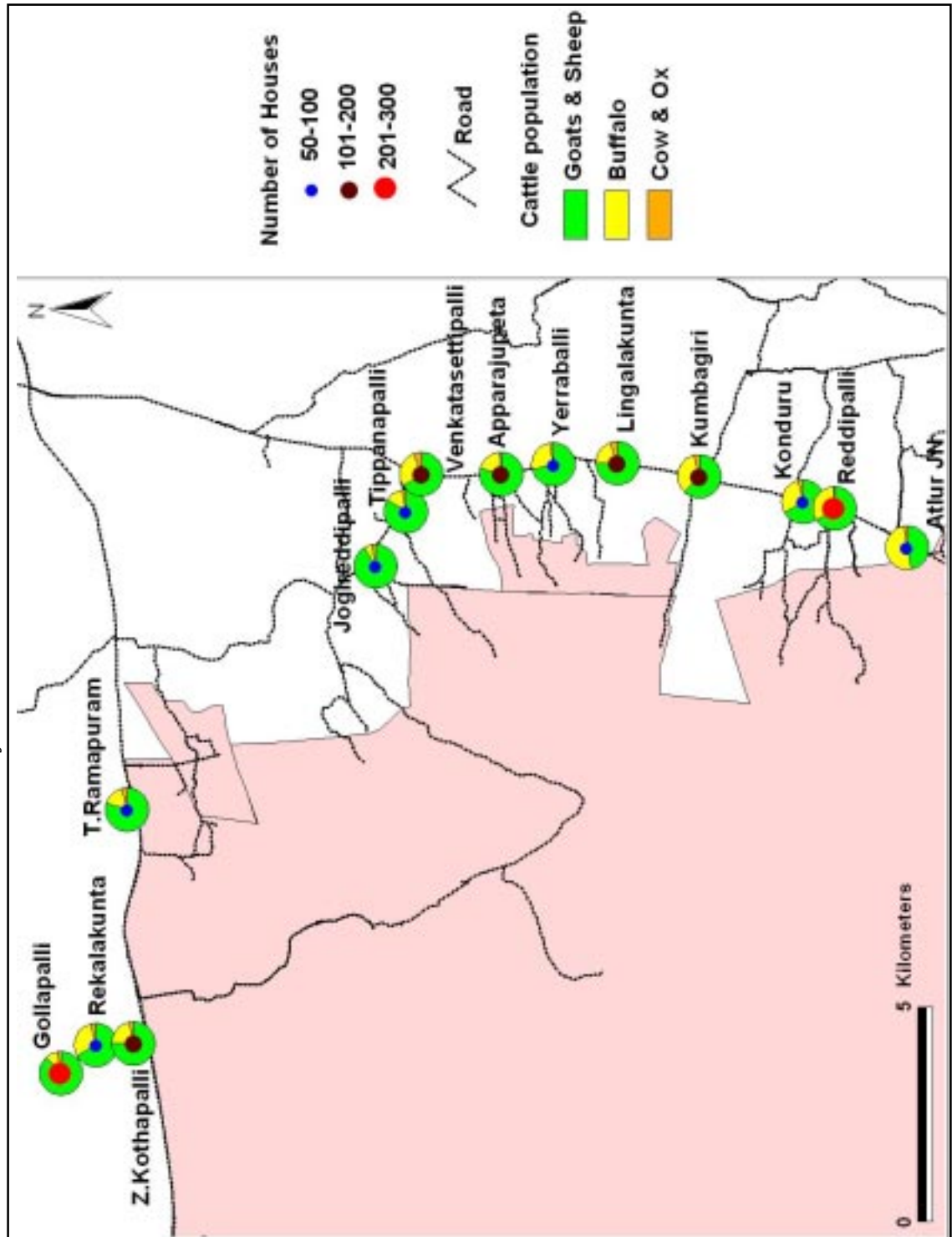


Table 7.2. Number of households and cattle population in 14 villages situated within 2 km from the eastern and northern * boundary of the Sri Lankamaleswara Wildlife Sanctuary.

Name of the Village	No. of Households	Buffalo	Goat	Sheep	Cow/Ox	Total
Jogireddypalli	70	70	732	343	34	1179
Thippanapalli	100	57	112	245	12	426
Venkatachettypalli	115	58	139	0	12	209
Apparajupeta	125	174	385	300	13	872
Yerraballi	68	76	90	120	9	295
Lingalagunta	128	76	212	82	23	393
Kumbagiri	143	166	147	151	19	483
Konduru	71	105	116	121	15	357
Atlur Jn	80	96	50	40	5	191
Reddipalli	300	752	252	1256	26	2286
T.Ramapuram*	72	60	162	143	16	381
Gollapalli*	210	52	271	221	15	559
Rekalakunta*	100	168	267	127	21	583
Z.Kothapalli*	102	257	652	206	29	1144
Total	1684	2167	3587	3355	249	9358

more than a thousand in three of the villages surveyed (Table 7.2 & Map 7.5). It should be noted that Andhra Pradesh Forest Department records indicates that grazing was permitted in the forest areas except for goats from the year 1968. A maximum of only four goats was legally permitted along with a heard of 100 and above sheep. However, it was observed that more than the permitted level of goats was taken for grazing inside the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries.

7.3.7 Use of forest by the villagers

Villagers around the Sri Lankamaleswara Wildlife and Sri Penusula Narasimha Wildlife sanctuaries were seen collecting fuel wood and fodder for cattle regularly from the sanctuary areas. It was also observed that people collected small timbers for agricultural purposes, house construction and for fencing. Particular sect of people collects bamboo *Dendrocalamus strictus* regularly, which occurs in the mixed deciduous forest in the Sri Lankamaleswara Wildlife Sanctuary. It was collected mainly to make mats and baskets. Bamboo was collected from the forest and transported to the villages by means of donkeys. Non Timber Forest Produces (NTFP) such as Honey, Gum from *Sterculia urens*, leaves of *Diospyros melanoxylon*, and *Bauhinia*

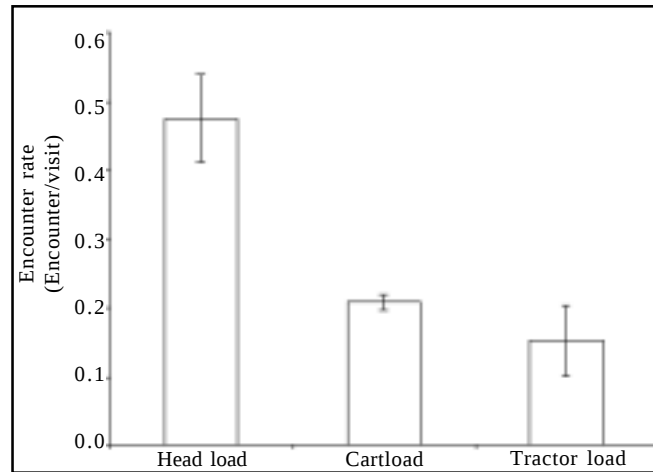
vahlii, barks of *Cassia fistula* and *Litsea decanensis*, seeds of *Strychnos nux-vomica* and *Sapindus emarginatus* were collected. Grass species such as *Cymbopogon citratus* was harvested for thatching and *Aristida setacea* for making brooms. Fruits of *Phyllanthus emblica* and *Phoenix humilis*, were collected from the forest area. Roots of *Hemidesmus indicus* and *Decalepis hamiltonii* were also collected seasonally. As far as the scrub jungle habitat was concerned fruits of *Diospyros ferrea*, *Gardinia gummifera*, *Manilkara haxandra*, and *Drypetes sepiaria* was collected seasonally and grasses were also harvested. These NTFP were collected by most of the villagers around the sanctuaries although the collection was permitted only for the members of Girijan Cooperative Corporation Ltd. who are generally tribal and poor people living near the sanctuaries.

During field visits to the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries observation of timber and non-timber forest products carried from the forest area by means of head loads, cartloads and tractor loads were noted from the year 2001-2003. It should be noted that this observation includes encountering people with fuel wood, wood collected illegally, grass, bamboo and other NTFP. Most of the NTFP, fuel wood, fodder leaves for cattle and single large timbers (DBH approximately 60 to 80cm) of c. 2-3m length were carried by head loads whereas large quantity of timbers, fodder leaves and grass were carried either by bullock cart or tractor. Such events were noted only if they are seen inside the forest roads. Although several hundred visits were made to the field these events were noted only during 256 visits (Table 7.3). My data collection of such exploitation was not very systematic, as only opportunistic data were collected. Of the 256 visits these events were encountered on 65% of the total visits. Mean encounter rate of the head load was higher (0.49 ± 0.06 per visit) while for the cartload and tractor load it was almost similar (0.21 ± 0.1 and 0.15 ± 0.05 per visit) (Figure. 1).

Table 7.3 Observation of collection of different forest produces from the Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries from 2001-2003. *n* is number of observations.

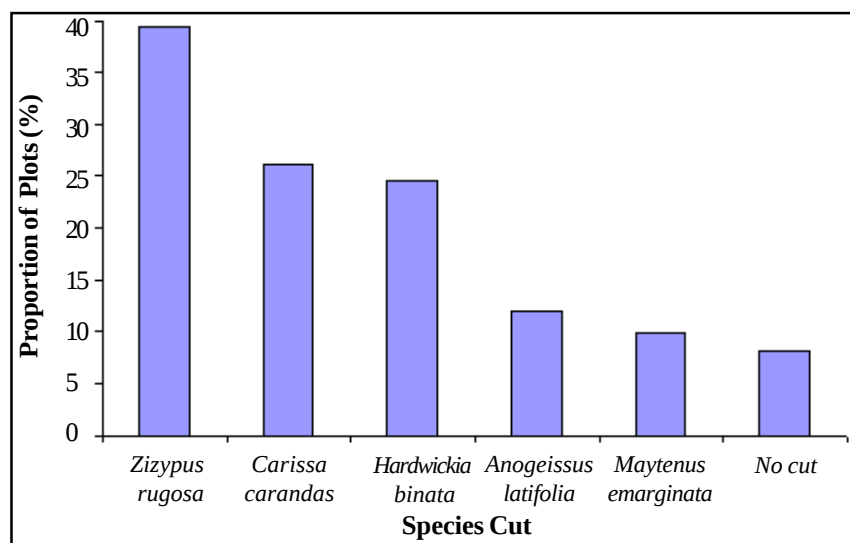
Year	Head load	Cartload	Tractor load	<i>n</i>
2001	22	9	9	43
2002	81	31	22	158
2003	22	12	6	55
Total	125	52	37	256

Figure 7.1 Encounter rate of head load, cartload and tractor load of timber and non-timber forest products carried from the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries observed 2001-2003. $n = 256$.



In the scrub jungle habitat, woodcutting was observed regularly. Mainly *Hardwickia binata* was pollarded during summer for thatching above the front door of the houses. Also graziers while taking their animals especially goats and sheep, inside the scrub jungle cut and bend the branches of scrub and tree species to facilitate better access for browsing. While doing the habitat recording in the 10 m square plots, cut marks of the species was noted. Totally 294 plots were surveyed and cut marks were noted in 28 species of scrub and tree species. Maximum of cut marks was observed in *Zizypus rugosa* (39 % of the plots surveyed). Only 8 % of plots surveyed without any cuts (Figure. 2).

Figure 7.2 Top five scrub and tree species in which maximum cut marks (> 10 %) seen in 10 m square plots ($n = 294$). Proportion of plots where there were no cuts was also given.



7.3.8 Illegal Bird trapping

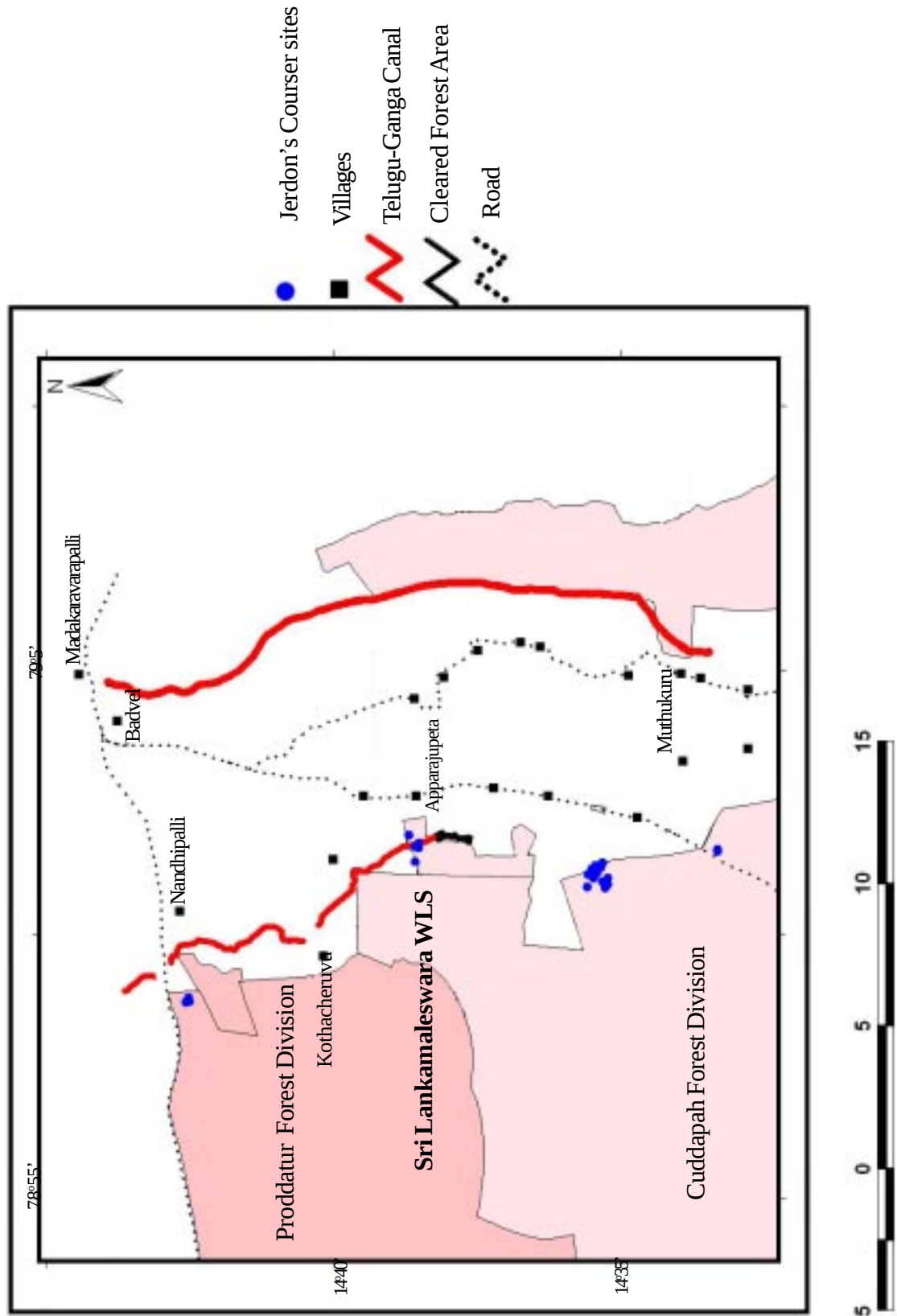
Illegal bird trapping by the particular sect of peoples in the peripheral areas of the eastern part of the Sri Lankamaleswara Wildlife Sanctuary was noticed on few occasions (<5 encounters on several hundred field visits in 4 years). It should be noted that on one occasion a bird trapper was seen near the main Jerdon's Courser area. Traps used by these trappers are nooses and nets and largely targeted for Grey Francolin *Francolinus pondicerianus* and Quail spp. which commonly occur in this area. Although trapping, exclusively for the Jerdon's Courser was not reported, it may be possible that it can be caught accidentally in the nooses and nets set for other bird species.

7.3.9 Telugu-Ganga Canal

At the time of the rediscovery in 1986, the Jerdon's Courser site was under threat because it was planned to construct the Telugu-Ganga canal across it. Officials from the Forest Department and the State Government of Andhra Pradesh recognized the ornithological importance of the site and declared it as Sri Lankamaleswara Wildlife Sanctuary for Jerdon's Courser, which included the rediscovery site on its eastern fringe. The proposed course of the canal was adjusted to avoid the Sanctuary (Bhushan 1995). Recently the canal construction was started for irrigating land in Sagileru River valley. The canal construction was noticed during the last week of October 2005 near Sri Lankamaleswara Wildlife Sanctuary. However, it was stopped by the Andhra Pradesh Forest Department since the canal was constructed in the forest areas without obtaining prior permission.

The origin of the Canal is from Sri Potuluri Veera Brahmendraswamy (SPVB) Reservoir near Bramhamgarimatam. This canal come southwards and ends 2 km away from Nandhipalli near Badvel - Mydukur road. It is also referred as Right Canal. Apart from this, one more canal is being excavated from Madakaravarapalli, which is c 1.5 km from Badvel. This canal goes southwards to the east of Sagileru river and it goes along the western boundary of Sri Penusula Narasimha Wildlife Sanctuary (Map 7.6). This part of the sanctuary falls under Cuddapah Forest Division. This canal is referred as Left Canal.

Map. 7.6 showing the route of Telugu-Ganga Canal in and around the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries in Cuddapah district, Andhra Pradesh.



The canal route and other disturbances while constructing the canal such as new roads to the canal sites and quarrying soil for canal construction in the forest area were documented from 21st to 28th November 2005. It should be noted that mapping was carried out mainly in the canals constructed, south of Maidukuru-Nellore road since this road forms as a northern boundary of Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries.

Canals were about 16 to 20 m wide, but the area cleared for preparing these canals differed from 80 to 100m. Stones and the soil was dug up by the Irrigation Department and piled all along the canal route. Roads were constructed on either side of the canal by using this soil as well as soil dug up from the near by area. Trees and shrubs, on the path of the canal route were uprooted and thrown aside. I mapped the canal route with the help of GPS by driving the jeep and/or walking through this road. Tracks of the canal route and other coordinates marked in the field were converted as Arc coverage. On the screen, simulated lines were drawn either side of the canal tracks for not less than 40m to mark the width of the area cleared. This was made as a polygon and the area was obtained. It should be noted that the area falling inside this polygon have different kind of habitats such as open ground, rocky terrain as well as scrub jungle. This coverage was kept as an overlay on the land-use/land-cover map of the study area to find out the habitat loss. For the place where there is a forest clear without canal it was mapped by walking along the forest clear. So the width was not simulated and the track itself transformed into a polygon and the area was obtained.

a. Right canal near Sri Lankamaleswara Wildlife Sanctuary

The Right Canal comes southwards from SPVB reservoir and ends 2 km away from Nandhipalli near Badvel - Mydukur road. The total length of the canal upto this point is c.22 km. Canal excavation continues from the other end of the road for about 5.8 km till a place called Anandanagaram. The canal excavation continued again leaving the gap of about 800m from the previous canal. This goes for about 5.6 km and ends inside the Yerraballi Forest block, Siddavattam Range, Cuddapah Forest Division. After 2 km from the starting point, it goes all along the Sanctuary boundary for about 1 km. After about 4.6 km, it enters into the Yerraballi Forest

block and passes through the block for about 900m. Apart from this canal, forest area has been cleared for the construction of the canal in and around Yerraballi Forest Block. Total length of this clear is c.1.6 km.

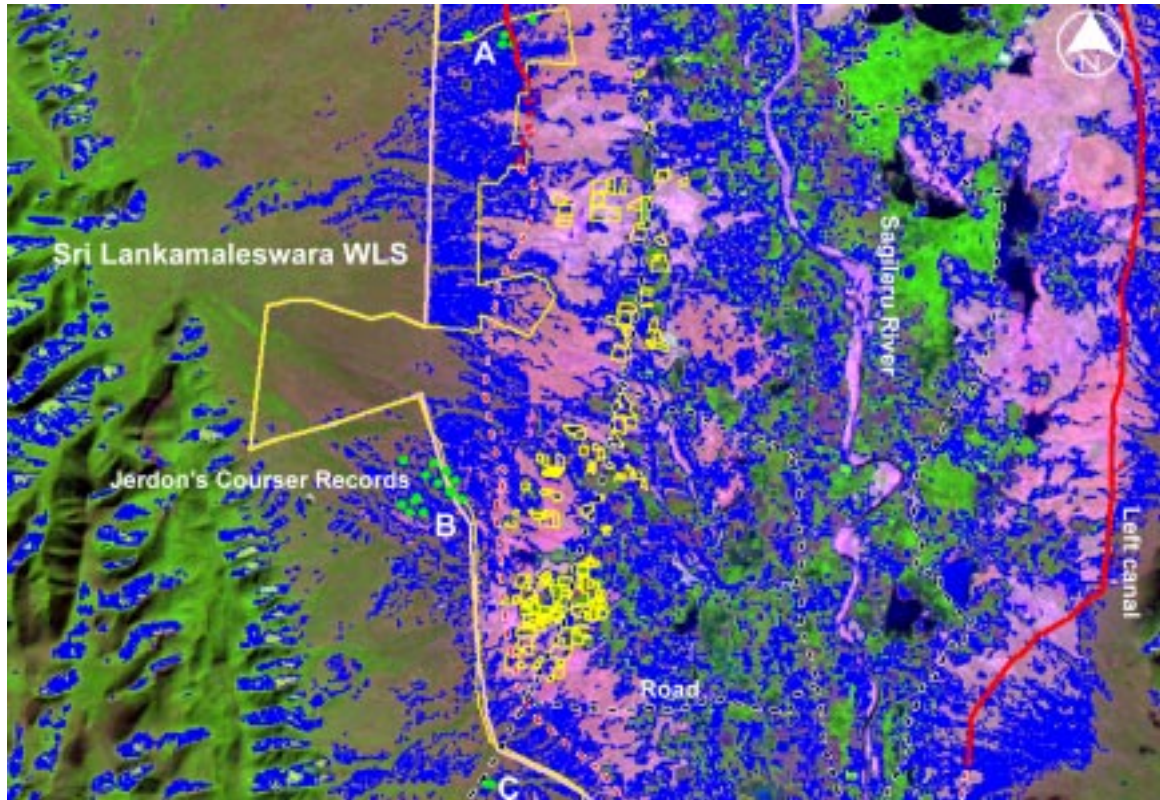
Total area cleared estimated for the Right Canal (from Nandhipalli upto Yerraballi Forest Block including the cleared forest area without canal) is 114 ha (Table 7.4). The second part of the right canal, which is from Kothacheruvu to Yerraballi Forest Block has destroyed c.15 ha. of scrub jungle which is potentially suitable habitat of Jerdon's Courser. It has also destroyed one of the places where Jerdon's Courser was recorded in 2001 by means of footprints, direct sightings, and calls. Apart from this, area cleared for the canal construction near Yerraballi Forest Block previously had c.7 ha of potentially suitable habitat. So in total c.22 ha of potentially suitable habitat of the Jerdon's Courser was lost due to the construction of the canal in the eastern part of the Sanctuary (Table 7.4).

Proposed route for the canal construction goes along the Sanctuary boundary and ends at 45 km from its origin near Atlur. More alarmingly when this canal route reaches its 40th km it goes very close (about 500 m) to the place where the Jerdon's Courser has been sighted regularly right from 1986. Scrub jungle in and around this area is the only place where Jerdon's Courser has been sighted frequently, footprints obtained and calls heard regularly. This is the only place in the world at the moment where the Jerdon's Courser is known to be present at almost all times. It was estimated that if excavations for the proposed canal progress further they would destroy c.650 ha of suitable habitat of the Jerdon's Courser around the Sri Lankamaleswara Wildlife Sanctuary (Map 7.7).

b. Left Canal near Sri Peninsula Narasimha Wildlife Sanctuary

The Left Canal excavated from Madakaravarapalli goes southwards to the east of Sagileru River and it goes along the western boundary of Sri Peninsula Narasimha Wildlife Sanctuary. Total length of this canal from Madakaravarapalli is c. 23 km. The canal goes very close to the Sanctuary boundary. In some places forest has been cleared and roads were made inside the

Map. 7.7 shows Landsat 7 ETM image of the study area with classified scrub jungle habitat overlayed onto it. Green dots with A,B & C marks indicates recent Jerdon's Courser records and Red dotted line indicate the proposed route of the canal. Yellow lines indicates the lemon farms. (Map not to scale).



Sanctuary area. Also in many places forest cairns have been damaged. Finally the canal comes to an end near the place called Muthukur. While the canal reaches its 21st km it entered Muthukur Forest Block of the Sanctuary area, which falls under Siddavattam Range, Cuddapah Forest Division. Length of the canal construction inside this Forest Block is about 2 km. It should be noted that since the construction was done without obtaining the permission from the APFD, so it was stopped on 25th October 2005.

Total area cleared estimated for the construction of the left canal in and around Sri Penusula Narasimha Wildlife Sanctuary is c. 163 ha. Forest area cleared inside the Muthukur Forest Block is c.8 ha. (Table 7.4) Except for this Muthukur Forest Block this canal route passes very close to the sanctuary boundary. Extensive favorable habitat is present at the foothills of Turupukonda in and around the Muthukur Forest Block.

Table 7.4 Details of area cleared for the canal construction, length of the canals and details of the loss of the potentially suitable habitat of the Jerdon's Courser in and around Sri Lankamaleswara and Sri Penusula Narasimha Wildlife Sanctuaries.

Sl. No.	Sri Lankamaleswar WLS	Areas in hectares	Length in Km
1.	Estimated area cleared for the Right Canal.....	114.0	
2.	From Nandhipalli to Anandanagaram.....	53.0	
3.	From Kothacheruvu to Yerraballi Forest Block (YFB).....	51.5	
4.	Forest clear without canal near YFB.....	9.5	
5.	Loss of potentially suitable habitat from Kothacheruvu to YFB.....	15.0	
6.	Loss of potentially suitable habitat in the Forest clear near YFB.....	7.0	
7.	Total loss of potentially suitable habitat due to the Right Canal Construction.....	22.0	
8.	Total Length of the Right Canal in and around the Sri Lankamaleswara WLS.....		13.0
9.	From Nandhipalli to Anandanagaram		5.8
10.	From Kothacheruvu to YFB.....		5.6
11.	Length of the Forest cleared in and around YFB.....		1.6
	Sri Penusula Narasimha WLS		
1.	Estimated area cleared for the Left Canal.....	163.0	
2.	Area cleared inside the Muthukur Forest Block.....	4.5	
3.	Total Length of the Leftt Canal in and around the Sri Penusula Narasimha WLS.....		23.0
4.	Length of the Left canal inside the Muthukur Forest Block.....		2.0

7.4 Discussion and Recommendations

About 2000 ha of scrub jungle habitat is present outside, mainly around the eastern boundary of the Sri Lankamaleswara Wildlife Sanctuary. It should be noted that this estimation was based on the classification of the December 2000 satellite image of the study area. Scrub jungle habitat clearances mapped around the Sanctuary from 2001-2004 shows that nearly 15% of this areawas destroyed. Jerdon's Courser was reported only from the scrub jungle habitat and it was established in this study that it prefers areas of scrub jungle with bush densities about 300-700 large (>2 m tall) bushes ha-1 and less than 1000 small (<2 m) bushes ha-1. Two samples of droppings were collected from the main Jerdon's Courser area during this study. Identity of the droppings were confirmed since one of these was present in between the footprints and another one was seen while it was produced by the Jerdon's Courser. It was found that these droppings

consist mainly of body parts of *Macrotermes* termites and ants. From two samples, it is difficult to establish the major food preferred by the Jerdon's Courser, however food of all the coursers are chiefly insects (Mason & Lefroy, 1912 and Maclean, 1996) and one study on stomach content analysis of Double-banded Courser, Burchell's Courser and Temminck's Courser in South Africa reveals that they feed exclusively on termites (Kok & Kok, 2002). Nothing is known of the breeding ecology of Jerdon's Courser (Birdlife International, 2001), but it should be a ground nester as other coursers (Maclean, 1996). Although no nest of the Jerdon's Courser was found during this study, observation of footprints of a young bird along with an adult Jerdon's Courser in one of the tracking strips deployed, suggests successful breeding in the study area.

Based on my studies on the ecology and behavior of the Jerdon's Courser I can say that it uses specific habitat type for feeding and breeding. Studies show that extinction risk of birds increase when habitat loss is severe especially for habitat specialists (Owens & Bennett, 2000 and Norris & Harper, 2004). Sekercioglu *et al.* (2004) predicted that insectivorous birds are more extinction prone than other groups. The Jerdon's Courser possesses other plausible traits, which can influence its extinction probability: small geographical range, small population size and occurring in lower elevation (Gaston, 1994, Purvis, *et al.* 2000 and Gage, *et al.* 2004).

Increasing settlements near the Sri Lankamaleswara Wildlife Sanctuary would pose severe threat in future as this would result in clearing more scrub jungle habitat, increasing livestock population and grazing as well as woodcutting. It should be noted that out of 14 villages surveyed around the Sri Lankamaleswara Wildlife Sanctuary maximum number of household and livestock population was recorded in Reddipalli, which is near the main Jerdon's Courser area (Map 7.5). Density of the human population in Cuddapah district in 2001 was 168persons/ sq km (Government of Andhra Pradesh, 2002). In India the human population density in 2001 was 313persons/sq km (Government of India, 2001a) and it is likely to increase to 426persons/ sq km in 2026 (Government of India, 2006). It was also predicted that by 2050, India would be the most populous country in the world (UN, 2004). Increasing household and population around the Sanctuary would pave way to intense use of scrub jungle habitat. Studies show that magnitude of

disturbance become more intense as the number of households increases, thus resulting in habitat alteration and deterioration (Liu *et al.* 2003 and Karanth *et al.* 2006). Exposure and proximity to high human population density would increase the extinction risk of plants and animals (Harcourt & Parks, 2003, Thompson & Jones, 2003 and Cardillo *et al.* 2004).

Highly populated areas, especially in rural India, are likely to have higher livestock populations. The total livestock in Andhra Pradesh has increased from 36.01 million to 48.20 million between 1999 and 2003 showing an overall increase of 33.8 % (Government of India, 2005). Increasing settlements near the Sanctuary would likely to bring more number of livestock in future as livelihood of most of the villagers are mainly cattle rearing, next to agriculture. In rural areas of India, the primary source of energy for cooking is fuel wood. Seventy six percent of the rural Indian households mainly depended on it (Government of India, 2001b). Encounter rate of carrying the several forest produces through head loads was higher when compared to cartload and tractor load in this study. It should be noted that though the head load category consists of carrying NTFP, grass and illicit wood, frequency of head load of fuel wood was more than that of other forest produces. Although moderate amount of grazing and woodcutting would benefit in maintaining the structure of the scrub jungle habitat preferred by the Jerdon's Courser, over grazing and intense human use would result in deterioration of the habitat. Several studies show that overgrazing lead to decline in forest cover, local extinction or emigration of animals dependent on specific vegetation cover, change in plant community architecture, change in the physical characteristics of terrestrial habitat (Qninn & Walgenbach, 1990, Fleischner, 1994, Blackmore & Vitousek, 2000, Madhusudan & Mishra, 2003).

Intense human use, overgrazing and increasing settlement would surely have a gradual negative impact on the scrub jungle habitat. However, immediate threat for the scrub jungle habitat around the Sri Lankamaleswara Wildlife Sanctuary is the construction of the Telugu-Ganga Canal. Although the Right Canal was stopped for the time being, it was estimated that if the canal continued as proposed by the Andhra Pradesh Irrigation Department it would have resulted in loss of c.650 ha of scrub jungle habitat.

The new Telugu-Ganga Canal poses at least three types of threat to Jerdon's courser:

1. Construction will destroy the remaining scrub jungle habitat of the Jerdon's Courser in the eastern part of the Sri Lankamaleswara Wildlife Sanctuary. Furthermore, because population survey work is at an early stage, other Jerdon's courser sites where the species has not yet been detected will also be destroyed. These losses of habitat will diminish the population. Absence of Jerdon's Courser records does not imply absence of the bird, as most of the areas outside the Sanctuary have not been surveyed yet. So, it is imperative to protect the potentially suitable habitat outside the Sanctuary.

2. The canal will permit the extension of irrigated agriculture to many areas outside the Sanctuary that are scrub jungle at present. Rapid replacements of forested landscapes by cultivated lands along with the change in cropping pattern has deteriorated the Jerdon's Courser's habitat. Major crops of this place were paddy, cotton and sunflower. But in recent times, lemon farms have replaced these as they need relatively less maintenance, and are lucrative. This has resulted in the clearing of the scrub jungle areas outside the Sanctuary. Scrub jungle will be cleared for this purpose and this will remove Jerdon's Courser habitat and diminish the population. Since December 2000, when my studies started, scrub jungle has already been cleared for agriculture up to the Sanctuary boundary in several places. (Map 7.1).

3. Extension of agricultural use will lead to increased human activity in and near the Sanctuary. In turn, this is likely to increase unauthorized human use of the Sanctuary and any remaining scrub jungle outside it. All known Jerdon's Courser sites are already used for grazing of livestock and woodcutting, but at moderate levels, which may help to maintain a suitable vegetation structure for Jerdon's Courser. However, increased use is likely to reduce the density of bushes below that suitable for the species. Other unauthorized uses of the Sanctuary include hunting of mammals and bird trapping. An increase in trapping is likely to lead to direct killing of Jerdon's Coursers.

7.5 Recommendations

7.5.1 Telugu-Ganga Canal

Steps taken by the Bombay Natural History Society and several other conservationists resulted in realignment of the Right and Left Telugu-Ganga Canal. The realignment proposed by the Andhra Pradesh Irrigation Department for Left Canal in the Sri Penusula Narasimha Wildlife Sanctuary avoids Muthukur Forest Block entirely. In the case of the Right Canal, proposed alignment from the 30th km, avoids Yerraballi Forest Block but passes precariously close to the main Jerdon's Courser area (<500 m) and would still result in loss of c.300 ha. scrub jungle habitat. So, two alternative canal realignments was suggested by the BNHS for the Right Canal near the Sri Lankamaleswara Wildlife Sanctuary, which would have minimal loss of scrub jungle habitat.

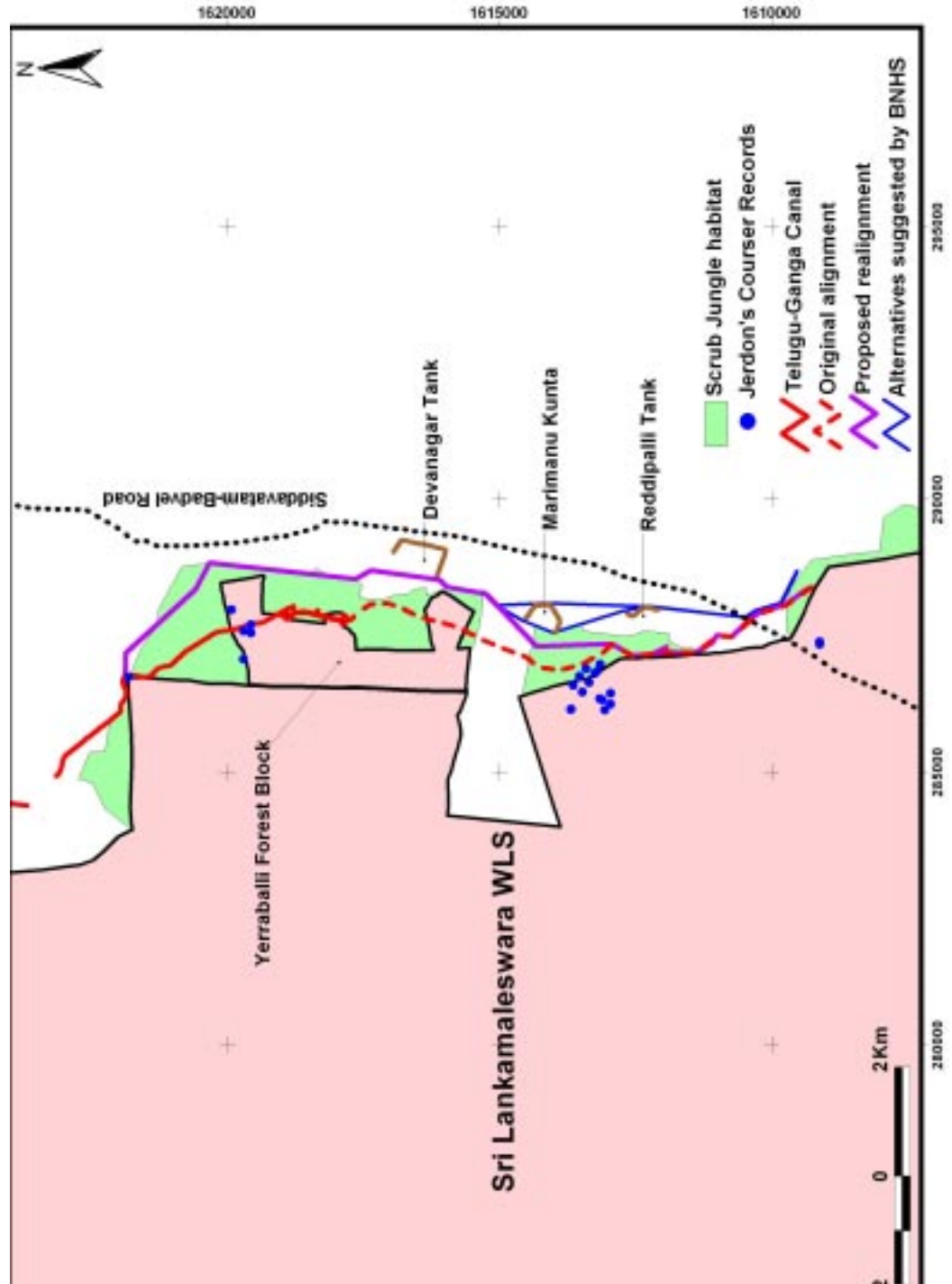
a. Alternative No. 1

The alignment of the proposed Right Canal should take off from above the Kumbagiri settlement, traverse at the base of Marrimanu Kunta and proceed directly to the base of Reddipalli Tank passing through its command area. From here it will join the canal alignment proposed by the Andhra Pradesh Irrigation Department at 43.351 km (Map 7.8 & 7.9). This alignment passes partly through and sometimes skirts the lemon farms and a stretch of scrub forest and wasteland till the base of Reddipalli Tank. Below Reddipalli Tank there is cultivated land with paddy in the command area, which is in a shallow depression and further south there are lemon farms on elevated land. If this alignment is followed it would result in loss of 64 ha of scrub forest and well away from the main Jerdon's Courser area (c. 1km).

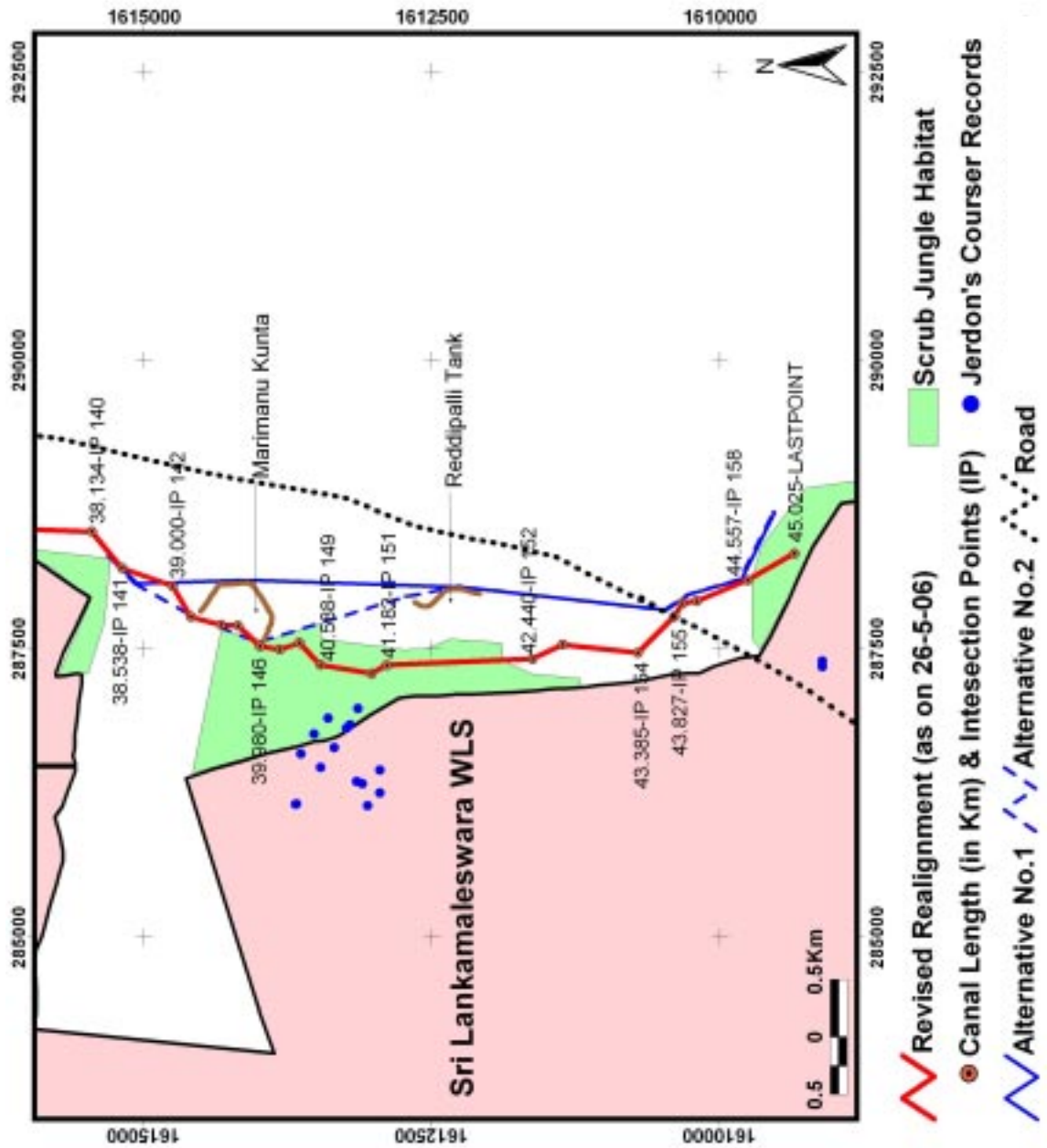
b. Alternative No.2

The second alternative is that the alignment should take off from the point above the northern end of the bund of Marrimanu Kunta, traverse along the foreshore of this tank and proceed southwards upto the base of the Reddipalli Tank and after passing through its command area and join alignment suggested as first alternative. This alignment passes through stretches of scrub jungle and extents of wasteland (Map 7.8 & 7.9) and this would result in loss of 68 ha. scrub forest.

Map 7.8 showing the present and proposed Right Canal alignments as per the Andhra Pradesh Irrigation Department and the two alternative alignments suggested by the Bombay Natural History Society.



Map 7.9 Enlarged view of the map showing the realignments of the Right Canal suggested by the Bombay Natural History Society



7.5.2 Recommendations for proper management of the scrub jungle habitat inside the sanctuary

In the Sri Lankamaleswara Wildlife Sanctuary and Cuddapah Division of Sri Penusula Narasimha Wildlife Sanctuary, scrub jungle habitat distributed in 9 Forest Blocks (in 55 compartments) as shown in Map 7.10 and listed in Table 7.5. There should not be any kind of forestry activities conducted in this part of the sanctuary since these areas are vital for the survival of the Jerdon's Courser. The measures suggested below should be followed for these areas:

1. Scrub jungle habitat inside the sanctuary should not be cleared for planting exotic species.
2. Percolation ponds should not be constructed inside the scrub jungle areas.
3. No planting should be done in the open areas of the scrub jungle.
4. Trenches should not dug inside the scrub jungle.
5. Singling and Thinning should not be carried out inside the scrub jungle.
6. Overgrazing should be controlled.
7. Illegal bird trappers around the sanctuary should be identified and measures should be taken to prevent hunting.
8. Unauthorized woodcutting should be restricted.
9. Forest staff appointed in sanctuary should be educated on the importance of the Jerdon's Courser and the scrub jungle habitat
10. Forest staff can be trained in listening the call of the Jerdon's Courser and also to do the tracking strip surveys.
11. Yanadi tribal community and local peoples can be engaged in preparation of the tracking strips and in identification of Jerdon's Courser tracks and calls.
12. Management plan should be prepared based on scientific studies exclusively for the Jerdon's Courser habitat in and around the sanctuary.
13. At least 2 Forest staff should be based permanently in Konduru Beat, near Reddipalli for regular monitoring for the main Jerdon's Courser are from the possible threats such as illegal bird trapping, woodcutting and quarrying.
14. Steps should be taken immediately to include the scrub jungle habitat present outside into the sanctuary area.

Map. 7.2 shows the distribution of the scrub jungle habitat in and around the Sri Lankamaleswara and Sri Penusula Narasimha wildlife sanctuaries. Forest Compartment numbers in which the scrub jungle occurs were also given.

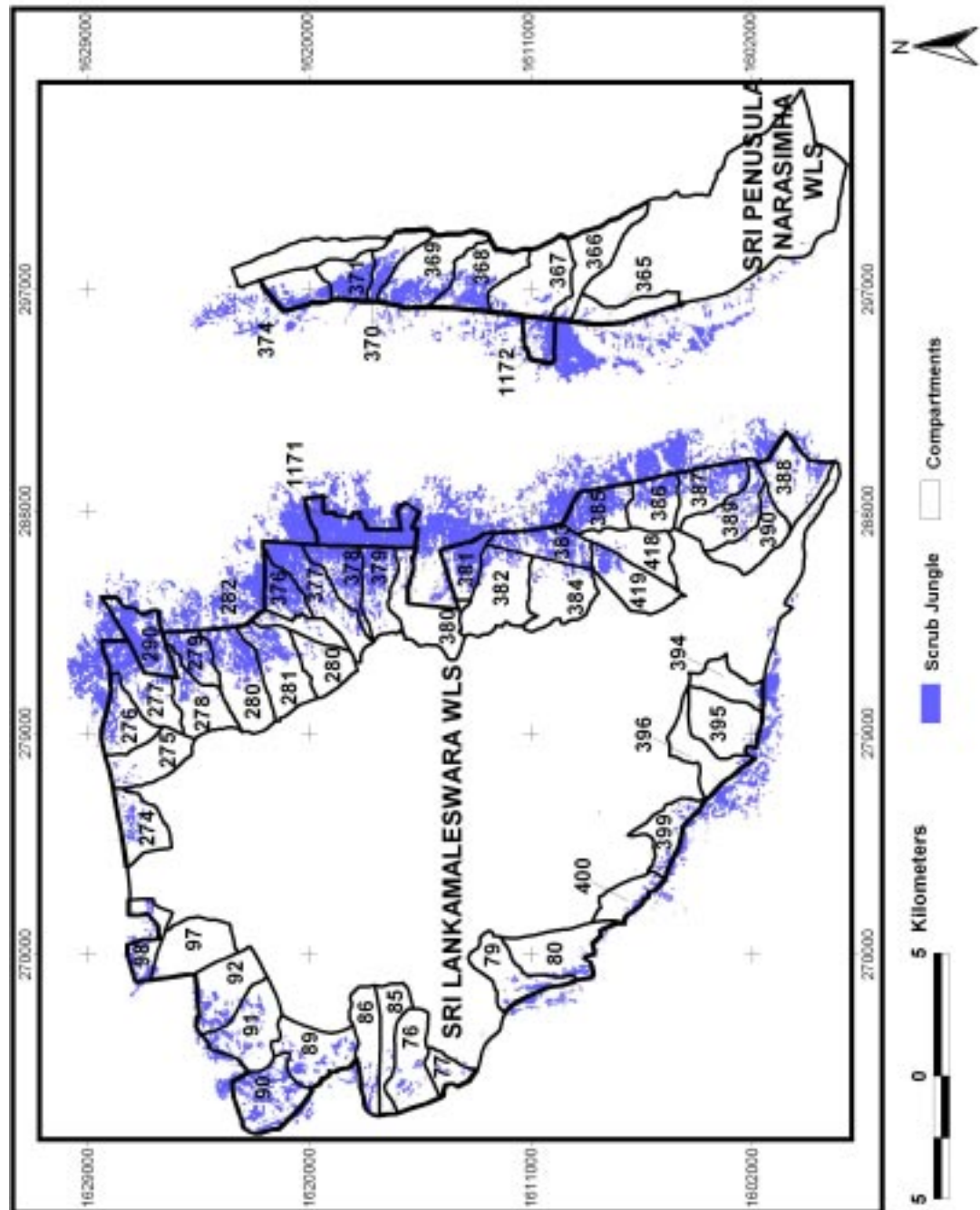


Table 7.5 Administrative details of areas where the scrub jungle habitat distributed in the Sri Lankamaleswara and Sri Penusula Narasimha* wild sanctuaries.

Division	Block Name	Block Code	Compartment Numbers
Proddatur	Chennamukkapalle Reserve Forest	19042	76, 77
	Lankamalai Reserve Forest	19043	79, 80, 85, 86, 89, 90, 91, 92, 97, 98
	Lankamalai Reserve Forest	19061	274, 275, 276, 277, 278, 279, 280, 281, 282, 283
	Gopalapuram Reserve Forest	19062	290
Cuddapah	Lankamalai Extension Reserve Forest	19079	376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 392, 394, 395, 396, 399
	Lankamalai Extension Reserve Forest	19080	400
	Lankamalai Reserve Forest	19080	418, 419
	Yerraballi Forest Block	19081	1171
	Turpukonda Extn Reserve Forest*	19077	365, 366, 367, 368, 369, 370, 371, 374
	Muthukuru Forest Block*	19082	1172

7.6 Future Research

7.6.1 Large Scale Habitat Mapping

To gather information on the spatial location of potentially suitable habitats in the places where the Jerdon's Courser has been reported historically, it is important to do large-scale habitat mapping. Bhushan (1994), Samant and Elangovan (1997) suggested localities of the presence of the species at confirmed and suspected sites in Andhra Pradesh. Satellite images of the corresponding areas should be analysed and classified. This would enable the establishment of new protected areas.

7.6.2 Survey to find the Jerdon's Courser in new areas and long-term monitoring

Surveys should be carried out in the places where there are confirmed and suspected records of the Jerdon's Courser by following the soil strip and tape playback methods. Surveys should also be carried out in the areas, which are identified from the satellite images through large-scale habitat mapping. Suitable habitats within the Sri Lankamaleswara Wildlife Sanctuary should be monitored in the long-term, for effective management.

7.6.3 Radio telemetry studies

Nothing is known about the population, ecology and behaviour of the Jerdon's Courser (BirdLife International 2001). The more we know about their habitat requirements, the sooner and more effectively can we conserve them. Radio tracking would reveal information about the ranging behaviour, from which detailed maps of their movements can be produced. Through radio tracking we can also gain knowledge about their feeding areas, roosting sites, and nest sites. Two samples of Jerdon's Courser droppings were collected during this study. It was found that these droppings consist mainly of body parts of *Macrotermes* termites and ants. Radio tracking will also help in locating faecal material for diet analysis once the bird has left the roost site. It would be helpful to determine whether this species' distribution is limited by the availability of a particular food species.

Nothing is known of the breeding ecology of Jerdon's Courser (BirdLife International 2001), no nests or young birds have ever been found. Though we have no direct evidence, the observation of the footprints of a young bird along with an adult Jerdon's Courser in one of the soil strips we deployed, suggests successful breeding in our study area. The usual way to locate the nests of ground-living birds is to observe an adult until it returns to its nest (Bibby *et al.* 2000). This is impossible in the case of the Jerdon's Courser, since it is nocturnal. The only way to locate nests would be to radio-track individuals. Radio tracking would also help to develop more efficient survey methods. For instance, it would be possible to measure the proportion of occasions on which radiotagged Jerdon's Coursers respond to tape recordings and whether they only do so at certain times of the year. It is possible to estimate the number of individuals present in an area by

measuring the ratio of untagged to tagged individuals responding to tape playback (Bibby *et al.* 2000). Since the number of tagged individuals is known, the total number of individuals present could be obtained using this ratio. It would also be possible to measure the proportion of occasions on which a radio-tagged Jerdon's Courser responds to tape playback by calling when it is within 250 metres. This estimate of survey efficiency would be useful to convert the results of tape transects directly to density estimates. Once density has been estimated in this way for a few study areas it would be possible to calibrate the soil strip tracking method so that the relationship between tracking rate and density is known. Hence, radiotracking Jerdon's Courser would help in assessing population size, as well as range. It is possible that individual Jerdon's Coursers occupy a home range within a known area for only some part of the year. Birds may migrate to other areas or habitats at different times of year. This possibility can only be investigated by radio-tracking. Radio tracking would reveal information about the Jerdon's Courser that could not be gained in any other survey techniques employed by the project during this study. The information gained from radio tracking would be of direct and immediate value for remedial management intervention.

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Appendix - 1

Synopsis

**SYNOPSIS OF THE THESIS TO BE SUBMITTED TO
THE UNIVERSITY OF MUMBAI
FOR THE DEGREE
OF
DOCTOR OF PHILOSOPHY
IN
ZOOLOGY**

Name of the Student:	P. Jeganathan
Registration number and date:	50/14.11.2002
Date of submission of the synopsis:	
Title of the thesis:	Ecology of the Jerdon's Courser (<i>Rhinoptilus bitorquatus</i>) in India.
Name of the Guide:	Dr. Asad R. Rahmani
Institution where research: was carried out	Bombay Natural History Society

Signature of Candidate

Signature of the Guide

Ecology of the Jerdon's Courser (*Rhinoptilus bitorquatus*) in India.

Introduction

The Jerdon's Courser *Rhinoptilus bitorquatus* (Blyth) (Charadriiformes: Glareolidae) is a small cursorial bird that inhabits open patches in the scrub jungle. It is nocturnal or crepuscular in habit. It was first described by T. C. Jerdon around 1848. Till 1900, some birds were recorded near Pennar river and Godavari river valleys, and near Anantapur (Baker 1929, Ali 1977). Subsequently, efforts by various ornithologists to record this elusive species were unsuccessful (Whistler and Kinnear 1930, Ali 1933-34). Special explorations organised by the Bombay Natural History Society (BNHS) in 1975 and in 1976 in collaboration with the Smithsonian Institution, Washington and Word Wildlife Fund-India, respectively, did not achieve positive results (Ali 1977). This led to the belief that the Jerdon's Courser was extinct (King 1981; Ripley 1982). Finally, it was rediscovered near Reddipalli village, Cuddapah District, Andhra Pradesh in January 1986 (Bhushan 1986a). The area where it was rediscovered was designated as the Sri Lankamaleswara Wildlife Sanctuary for the Jerdon's Courser (Bhushan 1986b).

The Jerdon's Courser has been observed regularly only at a few sites in and around the Sanctuary ever since it was rediscovered (Samant and Elangovan 1997). Except sight records, there is no data on current population size or geographical distribution. Furthermore, very little information is available on the ecology and habitat requirements of the Jerdon's Courser (BirdLife International 2001). Since the Jerdon's Courser is believed to have a small and declining population, it is categorised as Critically Endangered by BirdLife International (2001) and also in the IUCN Red List (Hilton-Taylor 2000). Furthermore, the Jerdon's Courser is listed under Schedule I of the Indian Wildlife (Protection) Act 1972, and more importantly it is considered as priority species under the National Wildlife Action Plan (2002 – 2016) of the Government of India (Government of India, 2002).

Study Area

The study was conducted mainly in the Sri Lankamaleswara Wildlife Sanctuary, Cuddapah District, Andhra Pradesh, India (14°45' to 14°72' N & 79°07' to 78°80' E), as well as in similar habitat, outside the Sanctuary boundary. Part of the study was conducted in the Sri Penusila Narasimha Wildlife Sanctuary (14°18' to 14°41' N & 79°05' to 79° 37' E), which is adjoining to the main study area. Geographically, these two sanctuaries lie between the Nallamalais and Sechachalam hill ranges in the Eastern Ghats.

Objectives of the study

The overall objective of this study was to undertake ecological research on the Jerdon's Courser to determine current population size and distribution, and identify current threats to the populations. This involved five specific objectives:

1. To design a proper and reliable census method,
2. To identify areas of suitable habitat within its known range and conduct survey to establish its current geographical distribution,
3. To examine habitat use to determine habitat requirements,
4. To assess potential threats,
5. To develop management plan and to make recommendations for its conservation based on survey findings, research and monitoring work, which includes the details of required conservation action, establishment of sites supporting populations as protected areas.

Organization of the thesis

In the chapter 1 general outline about the Courser family of the Indian subcontinent and its characteristic behavior, distribution and conservation status are given. Objectives and the rationale of this study are explained. Second chapter describes the study area. This chapter starts with an account on the Eastern Ghats and its salient features. Within the Eastern Ghats, the present study was conducted in two protected areas namely Sri Lankamaleswara and Sri Penusila Narasimha wildlife sanctuaries. Vegetation, climate, fauna and land use of these two study areas are described in this part.

Next four chapters deal with the major results of the study. Introduction to the particular topics of research, along with details of methods and analysis, are presented along in each of chapters.

In chapter 3, night-time search, which is the conventional method to detect the presence of the Jerdon's Courser, is assessed and its advantages and disadvantages are discussed. A new detection method, which was developed during this study is also described. This method involves deploying tracking strip upon which the birds leave their distinctive footprints. Diagnostic methods were developed for distinguishing the footprints of Jerdon's Courser from those of other species. Tracks of Jerdon's courser were obtained on about one strip-night in 30 from areas where the species was known to be present. Procedures are explained for using tracking strips to survey areas where Jerdon's Courser has not yet been detected.

The call of the Jerdon's Courser was unknown before this study. Chapter 4 describes the effort to record the call of the Jerdon's Courser. The short disyllabic call attributed to the Jerdon's Courser was recorded and identified within the Sri Lankamaleswara Wildlife Sanctuary. Details of the calling period, duration of the call and spectrogram are discussed in this chapter. Possibilities of conducting survey using pre-recorded tape calls through tape transect method and an attempt to identify the individual Jerdon's Coursers by calls were also discussed.

Chapter 5 explains the historical distribution of the Jerdon's Courser in India and survey efforts to locate the Jerdon's Courser in new areas by following the tracking strip and tape transect methods. Surveys using these methods have detected the species in the three new places. Landsat TM7 satellite image was used to know the extent of the presence of the suitable habitat for surveying. Also methods to identify the potentially suitable habitat from the satellite image are discussed in this chapter.

Chapter 6 discuss the study on the habitat preference of the Jerdon's Courser within the scrub jungle habitat. The number of bushes and trees within a 10 m square plot on 157 tracking strip, were counted and other attributes of vegetation and substrate in this area were described. Statistical models were used to describe the relationship between the tracking rate of Jerdon's Coursers and characteristics of the habitat around the strips by using ground based survey data. The results show that Jerdon's Courser has a strong preference for a particular density of scrub

jungle habitat and is most likely to occur where the density of large (> 2 m tall) bushes is in the range 300-700 ha⁻¹, and where the density of smaller bushes is less than 1000 ha⁻¹.

In chapter 7 details of the conservation issues prevail in and around the study areas are discussed. The scrub jungle habitat is under heavy anthropogenic pressures and the main threats identified are that the habitat destruction and alteration. This habitat is also affected by grazing with domestic livestock, woodcutting and clearing of bushes to create orchards and farmland. Extent of clearance was mapped and the amount of grazing and woodcutting were quantified and presented in this chapter. Based on the results of this present study recommendations are given. Large scale habitat mapping, long term monitoring of the existing sites where the Jerdon's Courser's were recorded and extensive surveys to find them in new areas and radio telemetry studies are the main suggestions for the future research. Jerdon's Courser was also detected outside the protected areas during this study. Protection of all suitable habitats outside the Sanctuary is emphasized.

*** Check references in the reference section.**

Preparation of Tracking strip

Stage 1. Tracking strip is marked with a string and then 5 m long x 25 m wide area is cleared of stones and vegetation.



Stage 2. Soil is levelled and sieved fine soil is laid along the line of a 5 m string to make sure that it is straight and of the correct length.



Stage 3. Fine soil is flattened into a strip 25 m wide and 1-2 cm thick using a builder's trowel and the surface is smoothened.



Stage 4. A very thin layer of soil from near the site is dusted onto the surface of the strip from a sieve to camouflage the shining appearance.



A view of the tracking strip along with the receiver/camera at the one end and transmitter at the other end.



Trailmaster camera photograph of a Jerdon's Courser triggered when the bird broke an infra-red beam. The bird is leaving footprints across a tracking strip.



Plaster cast of bird footprints showing differences in angle and length of the toes.



Footprint of the Jerdon's Courser (*Rhinoptilus bitorquatus*). The labels O,C,I and B mark the tips of the outer, central and inner toes and the hind margin of the foot, respectively.



Footprints of other cursorial bird species which lack the hind toe, recorded on the tracking strip, in and around the study area.



Footprint of the Indian Courser (*Cursorius coromandelicus*)



Footprint of the Red-wattled Lapwing (*Vanellus indicus*)



Footprint of the Yellow-wattled Lapwing (*Vanellus malabaricus*)



Footprint of the Stone Curlew (*Burhinus oedicnemus*)



Footprint of the Barred Buttonquail (*Turnix suscitator*)



Footprint of the Chestnut-bellied Sandground (*Pterocles exustus*)

A view of scrub jungle with open areas in Sri Lankamaleswara Wildlife Sanctuary.



Mechanical clearance of scrub jungle to create orchards and pastures are threatening the suitable habitat of the Jerdon's Courser



Trench inside the Sanctuary. Inappropriate management may affect the scrub jungle habitat.



Over grazing may result in deterioration of the scrub jungle habitat.



Clearing the scrub jungle habitat for lemon farming is increasing in and around the Sri Lankamaleswara Wildlife Sanctuary.



The Critically Endangered Jerdon's Courser is threatened by the Telugu-Ganga Canal.
Several hectares of scrub jungle habitat around Sri Lankamalewsara and
Sri Penusula Narasimha wildlife sanctuaries, was cleared for the canal construction.

